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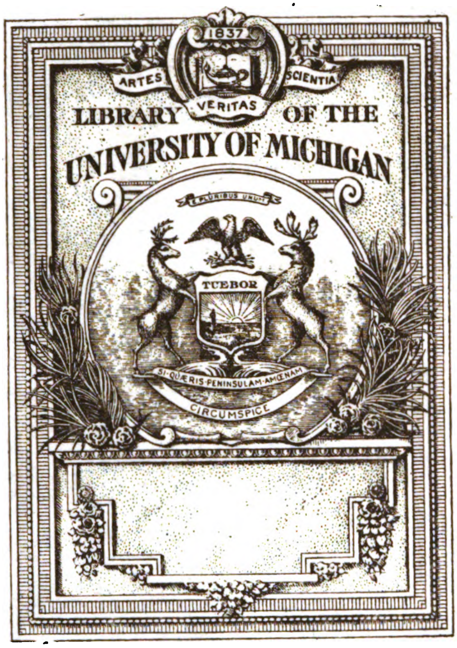
The adult Organisation of Paragordius varius (Leidy).

By

Thos. H. Montgomery jr.

With 7 Plates.

Jena,
Gustav Fischer.
1903.



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The adult Organisation of Paragordius varius (Leidy).

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aus den
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Paragordius varius is the most abundant species of Gordiacean in the eastern portion of North America, and on this account was selected for study. In the vicinity of Philadelphia, however, it is met with only infrequently and appears to be irregular and sporadic in its occurence. In the last parasitic stage I have found it in the abdominal cavity of *Acheta* (*Gryllus*) *abbreviata* only. In addition to the specimens secured by myself, and to those, in the Leidy collection, I am indebted to the following gentlemen who have sent me specimens and to whom I would here express my thanks: to my colleague, Prof. E. G. Conklin, to Professors H. S. Jennings and J. Reighard of the University of Michigan, to Prof. W. M. Wheeler of the University of Texas, to Prof. Ulrey of Manchester College, Indiana, and to Mr. C. W. Johnson of the Wagner Institute, Philadelphia.

The group of the Gordiacea, with the exclusion of the genus *Nectonema* Verrill, comprises the following distinct genera: *Gordius*, *Chordodes*, and *Paragordius*; a fourth genus has been established by Camerano (1897b) under the name *Parachordodes*; but it is certainly very close in its characteristics to *Gordius*, and until more important differences are found between the two than those mentioned by Camerano, we are hardly justified in assigning it separate rank. The genus *Paragordius* was founded by Camerano (1897b), and the same name proposed by me for the same species independently a short while after. In this paper (1898) I pointed out briefly and figured the most characteristic feature of *Paragordius*, namely the exceedingly long cloaca in the female. So far this is the only anatomical account of this genus.

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It is to **Vejdovský** that we owe the most important interpretations of Gordiacean structure. But the fact that his conclusions have not been generally accepted by the later workers has led me to make the present study, primarily to learn for myself what the facts of structure are. **Vejdovský**'s observations I can corroborate in most particulars; in regard to certain points of the anatomy I have been able to add to his account, particularly in regard to the structure of the nervous system; and in the interpretation of the affinities of the group I have reached somewhat different results. The contributions of **Vejdovský** mark a new epoch in the study of these forms; and since he has reviewed the literature bearing upon the anatomy and embryology, I shall not repeat this review, and in the discussion of different opinions upon mooted points, which are placed at the end of the description of each organ, I shall not go back in the literature beyond the time of the first paper by **Vejdovský**. In thus not considering the literature in detail previous to 1886, I intend in no way to undervalue the labors of earlier investigators; it is surely not necessary that each new contribution should give abstracts of all papers that have preceded it; and in regard to the genus *Paragordius* there is no previous anatomical literature, *Gordius* and to less extent *Chordodes* being the subjects of investigation. A nearly complete list of papers on the Gordiacea has been compiled by **Camerano** (1897b).

In regard to methods of study, it is to be noted that but little can be determined by clearing the whole animal in oil, owing to the opacity of the body wall. Almost all the following observations were made upon sections of $6^2/_3$ μ thickness, both transverse and longitudinal. Thinner sections than these cannot well be made owing to the hardness of the cuticle. It is necessary to imbed short pieces of the animal in hard paraffine for about an hour and a half. Serial series of sections through the head and tail regions, and through various intermediate regions of the trunk, were made of different individuals. 4 % formalin I found to be an excellent fixative, the best employed; corrosive sublimate solutions give very poor fixation, and the osmic acid fixatives do not penetrate in time to prevent the tissues from macerating. All the staining was done upon the sections on the slide; the double stain, **Delafield**'s haematoxylin followed by aqueous solution of eosin, gave very good results, but by far the best stain for sharp definition and especially for studying the nerve and muscle elements was the iron-haematoxylin method of **Heidenhain**. In addition to the preceding methods, hand dissection was employed to lay bare the nerve cord and intestine in their whole length, which succeeds after a little practice; this is very necessary in these worms which are too long to section in their whole lengths.

The present account deals with the anatomy of both sexes as found in the free state and towards the close of the parasitic period, i. e. when the muscular elements are fully differentiated and when the cuticle has its final thickness and color. One specimen of a male and one of a female in the "white" parasitic stage were examined also; but a description of these will follow later with an account of the whole embryology in so far as the necessary stages can be secured.

I. External characteristics.

The external appearance of this species has been described in detail elsewhere (MONTGOMERY, 1898; CAMERANO, 1897b), so that only a brief mention is necessary here.

In the female the body is cylindrical before the expulsion of the ova; the anterior and posterior portions are narrower than the middle. The head end (Pl. 1, Figs. 2, 4) is obliquely truncated, so that the ventral margin projects further forward than the dorsal; this terminal portion of the head is white, and just behind it is a black cervical ring; the color of the trunk varies from a light brown or yellowish to a dark brown. The posterior end of the body is trilobed, showing one dorsal, and two ventro-lateral lobes (Pl. 6, Fig. 78); the cavity between these lobes is the posterior end of the cloaca, so that the inner surfaces of the tail lobes may be called their cloacal surfaces. The dorsal lobe is more triangular on cross section (Pl. 5, Figs. 71, 73), the lateral more crescentic. Length up to about 290 mm.

In the male the head end (Pl. 1, Figs. 1, 3) is like that of the female, but the males are shorter and more slender than the females, and their color is generally darker. Further, the posterior end is bifurcated, with a pair of comparatively long, cylindrical lobes (Pl. 6, Figs. 81, 82); on the ventral surface of the body just in front of the junction of these lobes lies the cloacal aperture (*Cl. Ap*).

The oblique truncation of the head end and the black cervical ring behind it distinguish this species from the other local ones; as does the trilobation of the posterior end of the female, and the comparatively great length and slenderness of the tail lobes of the male.

II. Cuticula.

The cuticle covers the whole external surface of the body, and is continued inwards along the cloaca, in both sexes. It is a formation of the hypodermis. The superficial appearance of it and the distribution of its areoles have been described by me elsewhere (MONTGOMERY, 1898), so that it is not necessary to redescribe them.

At all points on the external surface the cuticle shows two distinct layers, which may be described separately as the inner or fibrous, and the outer or non-fibrous cuticula.

The fibrous cuticula which lines the outer surface of the hypodermis, is composed of successive layers of fibres. The fibres of one layer are all parallel, and their long axes cross the long axis of the body at an angle; the fibres of the next layer cross those of the former at an angle (Fig. 40, Pl. 3, on surface view where the arrow denotes the long axis of the body). They are thus not arranged in concentric circular layers as a hasty examination of cross sections would lead one to suppose. Cross sections (*F. Cut* Figs. 37, 41, Pl. 3) show that each layer of fibres has a definite boundary, and contains its fibres arranged in a single row; and these cross out fibres appear rounded or more often primatic. The number of these layers is greatest where the cuticle is thickest, and in the female there are as many as eleven of these layers. Besides these layers of finer fibrils, are found not continuous but irregularly disposed layers of larger fibrils (Fig. 37). This fibrous cuticle has a very elastic and firm consistency, and no radial pores or canals were found in it even after the closest examination. It is thinnest on the ventro-lateral sides of the head (*F. Cut* Fig. 10, Pl. 1), where its layers are also very thin but apparently as numerous as elsewhere; on the outer surface of the tail lobes of the female it is thinner than in other parts of the trunk, and contains fewer layers (Fig. 41 *F. Cut*). It is everywhere sharply demarcated from the underlying hypodermis (*Hyp*), so that in the free state of the animal its process of formation is complete. The black cervical ring at the anterior end of the animal is due to a dark color of the deeper layers of the cuticle in that region (Figs. 1, 4, Pl. 1).

The fibrous cuticle of the male differs from that of the female in being thicker and containing more layers. In the male particularly on the ventro-median surfaces of the tail lobes are found imbedded in the fibrous cuticle small, rounded bodies which stain deeply with iron-haematoxylin (Fig. 43, Pl. 3; Fig. 52, Pl. 4). They appear most frequently grouped in pairs. These are apparently not morphologically connected with the roots of the tubercles (*Tub* Figs. 43, 52) of the outer cuticle, though they stain in the same manner. Similar bodies are found in the tail lobes of the female, but less abundantly and there in some cases they appeared to be connected with the hairs of the outer cuticle.

Outer cuticle of the female. This (Pl. 3, Figs. 37, 41) bounds the outer surface of the fibrous cuticula (*F. Cut*), and consists of an outer homogeneous layer (*H. Cut*) and an inner areolar layer (*A. Cut*). The former is a thin layer, dense and homogeneous, found at all portions of the external body surface; it differs chemically from the fibrous cuticula, and evidently is the first portion of the cuticula to be formed. At the points just above the lines of separation of the underlying areoles it shows thickenings (Fig. 37); on the outer surface of the tail lobes (Fig. 41) and on the mid-ventral region of the trunk these thickenings are more pronounced, appearing as little cones. On both the outer and the inner surfaces of the tail lobes delicate hairs project outward from this homogeneous layer (Fig. 41). By the use of the iron-haematoxylin stain it can also be determined that the inner surface of the homogeneous layer, particularly in the region of its thickenings shows on cross section rounded and rod-shaped, deep-staining bodies (Figs. 37, 41). These are arranged in a single layer, are mainly interareolar in disposition, and appear to be a sculpturation of the inner surface; where the areolar layer is lacking beneath the homogeneous layer of the cuticle, the layer of these small bodies is continuous. The areolar layer of the outer cuticle (Figs. 37, 41 *A. Cut*) is lacking only on the anterior (Fig. 10, Pl. 1) and ventrolateral regions of the head, on the mid-ventral region of the trunk, and on the inner (cloacal) surfaces of the tail lobes. In it are found large homogeneous bodies (Pl. 3, Figs. 37, 41 *Ar*) which correspond to the areoles of surface views; they are largest on the outer surfaces of the tail lobes (Fig. 41). On surface view they appear rounded or oval, and more or less quadrilateral on cross sections of the body. They show more affinity for haematoxylin than for eosin. The nature of these areoles is hardly to be determined from the adult anatomy; but it may be suggested that they represent masses of glandular secretion poured out by the hypodermal gland cells (Fig. 41 *Gl. C*), after the homogeneous layer of the outer cuticle has been formed, and before the development of the fibrous cuticle.

Outer cuticula of the male. The areolar layer is lacking on the mid-ventral line of the whole trunk, as in the female, on the medio-ventral surfaces of the tail lobes (Pl. 3, Fig. 43, Pl. 4, Figs. 47, 52), and the anterior and ventro-lateral surfaces of the head. In the regions where the areolar layer is lacking, except on the head, the homogeneous layer of the cuticle shows a differentiation of elevated tubercles (*Tub* Figs. 43, 42, Pl. 3; Figs. 47, 52, Pl. 4). These are limited to the mid-ventral region of the trunk and the inner surfaces of the tail lobes (Pl. 7, Fig. 85). Their height, arrangement and number varies in different individuals. They are largest and most numerous just anterior to the cloacal aperture; on the ventral surface of the trunk they are sometimes arranged in two rows, one on each side of the median line (*Tub* Figs. 83, Pl. 6; Figs. 86—89, Pl. 7). Each larger tubercle consists of a base formed by a thickening of the homogeneous layer of the cuticle, and the tubercle proper which is imbedded in and projects above the latter (Pl. 3, Fig. 43; Pl. 4, Figs. 47, 52); the homogeneous layer of the cuticle (*H. Cut*) does not cover the projecting portion of the tubercle. The substance of the tubercle proper is yellowish and hyaline naturally (Fig. 44), but with the iron-haematoxylin stain it colors more deeply than the homogeneous layer of the cuticle (Figs. 43, 47, 52 *Tub*). Anterior to the cloacal aperture each tubercle is somewhat finger-shaped, and often several tubercles are closely grouped upon one base, as the teats upon the udder of a cow (Figs. 44, 89 *Tub*). Basally each tubercle sends branching roots into the fibrous cuticula (the cuticula has no areolar layer where these tubercles occur), some of which pass inwards almost to the hypodermis, while others bend at an angle and course between the fibrous layers (Pl. 3, Fig. 43; Pl. 4, Figs. 47, 52). I was unable to find any connection of nerve fibres with such processes. Only with the iron-haematoxylin stain can these roots be seen clearly, and then very sharply; though these tubercles thus extend into the fibrous cuticle, they would seem more properly to belong to the outer cuticle.

There is thus a well-marked sexual difference in the structure of the outer cuticle. The male alone shows the tubercles so characteristic of the genus *Chordodes* (but not the club-shaped processes of the latter), but only upon the cuticle of the ventral surface and the inner sides of the tail lobes. The function of these tubercles has not yet been explained, though they have been used to very great extent as distinctive characters by the systematists. They might aid the sense of touch, might serve to hold copulating individuals more firmly together, might serve to attach the animal more firmly to plants when in the free state. Now in the genus *Gordius*, tubercles and hairs are limited to the male, and to the region of the cloacal aperture and the inner surface of the tail lobes; in *Paragordius* to the male, to the inner surface of the tail lobes, and the mid-ventral region of the trunk; in *Chordodes* they occur in both sexes, and are found over the greater surface of the body. Perhaps this series may be a parallel to their phylogenetic development. In that case they would have first arisen in the vicinity of the cloacal aperture of the male, and hence their first function would have been to hold the female in copulation (which is accomplished in the Nematodes by means of spicula). From that part they have come to extend over the ventral surface forwards, then over the whole surface of both sexes. Presumably such tubercles would irritate the internal organs of the host much more than a smooth tubercle; and since such tubercles are developed towards the close of the parasitic stage (the first cuticle being smooth), they might hasten the death of the host so as to allow the quicker escape of the worm; in that case they might have been fostered in the genus *Chordodes* by natural selection.

Literature on the cuticula. The external cuticula has been treated to some extent by all describers of species of Gordiacea; for the external sculpturation offers fairly good specific differences, as VILLOT (1874) first pointed out. It is not necessary to repeat these descriptions of mere surface views. VEJDOVSKÝ (1886, 1894) distinguishes two layers of the cuticula; the outer "homogene", and the inner "faserige"; pore canals and sense hairs are described. VILLOT (1874, 1887) uses for the outer cuticula the term "épiderme", for the inner, "derme". CAMERANO (1888a, b, 1897b) distinguishes in the "cuticula" a "strato esterno" and a "strato fibrillare"; he also finds pore canals. VON LINSTOW (1889) uses the term "Cutis" for the fibrous layer of the cuticle, and "Epidermis" for the outer layer.

III. The Hypodermis.

The hypodermis of the female has been studied more carefully than that of the male, and the following description applies to the female unless otherwise stated.

The hypodermis (*Hyp* of the figures) lies immediately beneath the cuticle, and at the posterior end of the body is continued inwards as the epithelial lining of the cloaca. It is thickest in the ventral and lateral regions of the head (Figs. 1, 3, 4, 6, Pl. 1; Fig. 17, Pl. 2), where it constitutes a much modified sensory epithelium, and also where it forms the anterior wall of the eye (*E.Hyp* Figs. 1, 3, 6); these regions will be described under the headings "Nervous system" and "Eye". This thickening on the ventral surface of the head becomes lower behind the head, and in the trunk region posteriorly to about the plane of the atrium the hypodermis is much more flattened. But through this extent of the trunk, while it becomes very much flattened on the lateral aspects of the body, it is elevated into a ridge in the medio-ventral line, just at the point of attachment of the neural lamella (Figs. 13, 14, Pl. 1; Fig. 17, Pl. 2); and another thickening occurs in the medio-dorsal line, this dorsal thickening being broader but not so high as the ventral ridge (Figs. 13, 14, 16, Pl. 2; Figs. 61, 64, Pl. 4; Fig. 65, Pl. 5). Behind the plane of the atrium (Fig. 74, Pl. 5) in all the region of the cloaca (Fig. 72) and the tail lobes (Figs. 71, 73), the hypodermis becomes higher, so that both in the mid line and the lateral aspects it has the same thickness; consequently, in passing backwards from the plane of the atrium one finds that the medio-dorsal and medio-ventral thickenings disappear. The latter thickening diminishes in height gradually from the head region backwards.

The cellular components of the hypodermis are: large cells which are the producers of the cuticula, and may be termed the cuticular cells; gland cells; and nervous elements, which occur in the form of nerve cells, of terminations of the fibres of the chromophilic nerve cells of the central system, and of sensory cells. All these nervous elements will be described under the heading "Nervous system".

The cuticular cells extend from the cuticula inward to the muscular layer (or to the parenchym where that layer is lacking), and form a layer one cell thick (*Hyp* Figs. 13, 14, Pl. 1; Figs. 15—17, 22, 24, 25, Pl. 2, Figs. 27, 28, Pl. 3; and other figures). In the head region these are exceedingly elongated (*Hyp* Figs. 1, 6, Pl. 1), and to a gradually diminishing degree in the medio-ventral line of the trunk also (Fig. 13, Pl. 1; Figs. 15, 17, Pl. 2); such cells represent a particularly modified sensory type of the cuticular cells, and they are characterized in addition to their length by their being clearly separated from one another with narrow intervening spaces. Everywhere else in the trunk region as far back as the plane of the atrium, that is everywhere dorsally and laterally, these cuticular cells are more flattened, wider than high, and without separating membranes (*Hyp* Figs. 22, 24, 25, Pl. 2; Figs. 37, 42, Pl. 3). The nuclei (*Hyp.N*) of the cuticular cells are the largest that occur in the hypodermis, generally rich in chromatin and with one true nucleolus; in the much flattened hypodermis of the sides of the trunk the nucleus also is flattened with its long axis parallel to the surface of the cuticle (surface views of such nuclei show them to be disc-shaped and more or less oval in outline, *Sen.C* Fig. 40, Pl. 3). The cytoplasm varies in structure from a dense, almost homogeneous appearance to a more or less vacuolar, and is sharply bounded from the cuticle showing that the latter does not continue to be produced during the mature existence.

In the posterior region of the trunk, from about the region of the atrium backwards and most pronounced on the tail lobes, the cuticular cells have a different character, being longer and the cytoplasm appearing striated (*Hyp* Figs. 41, Pl. 3; Figs. 71, 73, Pl. 5); here evidently the cuticular cells have preserved more of an embryonic character, and have become less modified and degenerate; and here too the cuticle is thinner, and the process of cuticularisation apparently not completed.

The gland cells (*Gl.C* Fig. 41, Pl. 3) are found most abundantly upon the outer surfaces of the tail lobes, and do not appear to extend much forward of the plane of the atrium. They are narrower than the striated cuticular cells between which they lie, with a smaller rounded nucleus lying at about the middle. The following appearances of them may be interpreted as successive stage in the process of secretion of one kind of cell (Fig. 41): 1) the cell body without secretion, the cytoplasm clear and almost homogeneous so that the nucleus appears most distinctly; 2) a succession of stages where the secretion, which stains with haematoxylin, appears as smaller and larger globules within the cell body, gradually filling the cell and hiding the nucleus, terminating in a stage where one finds in the place of the cell an irregular, rod-like mass of deep staining secretion. These cells show no ducts or apertures passing into the fibrous layer of the cuticula, and since their secretion is not poured out between the hypodermis and the cuticle (there being indeed no space for it there), they probably have no functional value after the fibrous cuticula has been formed. And evidently even in the tail lobes, where the hypodermis has preserved more fully than elsewhere its original character, they are for the most part degenerate in character, an irregular mass of secretion being usually all that is left to mark the gland cell. The formation of the fibrous layer of the cuticle would appear to have caused their degeneration, by hindering the outflow of secretion. In the more anterior trunk region where the hypodermis is still more degenerate, are found only small dark bodies to represent these cells. But probably it will be found by a study of the embryology that on an earlier stage these gland cells are found in the whole trunk region, and degenerate last on the surface of the tail lobes. As has been suggested in the section "Cuticula", the areoles of the cuticle may represent masses of secretion poured out by these gland cells before the formation of the fibrous layer of the cuticula.

In the male the hypodermis of the head region is as in the female, but in the anterior trunk region the medio-dorsal thickening is much more pronounced (Fig. 83, Pl. 6; Fig. 90, Pl. 7). Through the greater portion of the trunk region it appears to be much the same as in the female, although I have not examined it so carefully in the male, except that the cuticular cells of the medio-dorsal thickening are proportionately very large with large rounded nuclei. But the structure of the hypodermis on the tail lobes of the male is quite different. The hypodermis on the dorsal and outer aspects of these lobes is not striated nor heightened, but much as in the more anterior regions of the trunk; and the latero-ventral hypodermis, next to the caudal nerve, is much heightened and sensory (*Hyp* Fig. 43, Pl. 3; Figs. 46, 47, Pl. 4), some cells of a type not found in the female (cf. the section "Nervous system").

Literature on the hypodermis. VEJDOVSKÝ (1886) finds the "hypodermis" to be a true epithelium in the anterior and posterior body regions, elsewhere "eine feinkörnige, mit zerstreuten Kernen versehene Matrix"; only one kind of cells were noted by him. In another paper (1894) he describes the metamorphosis of the hypodermis, finding true gland cells in it, and shows it to be very degenerate in the adult condition, due to the gradual formation of the fibrous layer of the cuticula. VILLOT (1874) considers the hypodermis to be a peripheral nervous layer, made up of a network of ganglion cells; in another paper (1887) he reiterates, in opposition to VEJDOVSKÝ, that there is no nucleated hypodermis in the adult, but a fibrillar layer of nervous nature; and finally (1889a) he concludes that there is a true cellular hypodermis in young stages, and that subsequently the cells, "ramifiées et anastomosées, ne représentent pas, comme je l'avais cru d'abord, une système nerveux périphérique, mais bien un appareil aquifère, qui communique avec l'extérieur par les canalicules et les pores de la cuticule". No other writer has confirmed either of these views, though JAMMES (1894) agrees with VILLOT in interpreting the hypodermis as a nervous layer. MICHEL (1888, 1889) demonstrates cell boundaries in the hypodermis, which, hovewer, were already known at the time of his writing. CAMERANO (1897b and previous papers) described the hypodermis, under the name "strato epidermico", as a layer "con cellule a grossi nuclei e con margini sinuosi". ROHDE (1892) terms the hypodermis "Subcuticula", as do many writers on Nematoda, and defines it as a "körnig-fibrilläre" protoplasmic mass with nuclei. None of these investigators have demonstrated in the hypodermis sense cells, or nerve fibres, or nerve cells.

IV. Muscular System.

A. In the Female.

The musculature consists of longitudinally directed cells only, and forms a sheath (Figs. 2, 3, 14, Pl. 1; Figs. 61, 63, 64, Pl. 4; Figs. 65, 66, 68, 70—75, Pl. 5) just below the hypodermis (*Hyp*), absent only in the most anterior region and at the ends of the tail lobes. Cross sections show that it is a layer interrupted only in the mid-ventral line, where it is interrupted by the neural lamella that connects the nerve cord with the hypodermis; at that point the muscle cells are deflected upwards on either side of the neural lamella, which deflection has been produced by the nerve cord separating from the hypodermis and breaking through the musculature. In the mid-dorsal line of the greater region of the trunk the muscle elements are not arranged in as close a grouping as elsewhere, but still show no interruption. Anteriorly the muscle sheath extends forwards to about the plane of the ventral commissure of the brain (*Musc* Figs. 2, 3, 7, Pl. 1); and at this point only the attenuated ends of the muscle cells are to be seen, and their number is comparatively small. More posteriorly, throughout almost the whole trunk region, the muscle cells are closely grouped together, most closely on the lateral aspects of the body wall, so as to be greatly flattened by close apposition (Fig. 37, Pl. 3). In the tail lobes the musculature is found only on the outer surface of the lobes (Figs. 71, 73, Pl. 5), which is clearly understandable, since these lobes may be regarded as simply due to a splitting of the posterior end of the trunk. The muscle cells are largest (highest) and most numerous at the middle trunk region. There is a single layer of muscle cells; but since the muscle cells have not a length equal to that of the whole body, the attenuated ends of some are to be seen between the enlarged middle portions of others.

Each muscle element is one cell with an axial, greatly elongated, cylindrical or ribbon-shaped nucleus, sometimes more or less lobular (*N* Fig. 38, Pl. 3); these nuclei are rich in chromatin and very easily demonstrated by suitable stains. Around the nucleus and forming the axis of the cell is the non-contractile core, containing a faint-staining cytoplasm generally in the form of an irregular network of fine strands (***Musc*** Fig. 25, Pl. 2; Figs. 37, 42, Pl. 3); this core seems to extend not quite to the attenuated ends of the cell. The periphery of the cell is contractile, consisting of longitudinally directed fibrils arranged in a single layer. The iron-haematoxylin method enables one to determine the finer structure of this part with great accuracy. At the attenuated ends of the cell such fibrils are found at all points of the periphery, and this is true of their arrangement along the greater part of the cell. But at about the middle point of the cell, where the nucleus is found, the cell often appears on cross section to be bounded by two parallel rows of fibrils, such fibrils being absent on the edge of the cell contiguous to the hypodermis as well as on that edge next to the body cavity (Fig. 37, Pl. 3). This is generally the case with the much flattened cells of the lateral body wall; and at these parts of such cells the non-contractile core appears to be uncovered by a contractile sheath. It is probably at such points that the motor nerves reach the muscle cells from the hypodermis. Though, as will be shown later, nerve endings could not be found upon the muscles owing to the lack of success in properly differentiating by stains the motor nerves, yet the motor nerves probably pass into the hypodermis from the nerve cord by way of the neural lamella, since the sensory nerves have been demonstrated to take this course. Hence the innervation of these muscle elements is most probably from the hypodermal side, and not, as in the Nematoda, from their inner surfaces. Possibly intra-vitam staining with methylene blue would finally settle this point.

Cross sections of the muscle cells arranged on the lateral aspect of the trunk, show for the contractile zone of each cell the fibrils generally quite regular in diameter, arranged in one row on the boundary of the cell, and appearing generally small and rounded or polygonal (Fig. 37, Pl. 3). But in those muscle cells of the medio-ventral region of the trunk (*Musc* Fig. 25, Pl. 2), and to less extent those of the medio-dorsal (*Musc* Fig. 42, Pl. 3), the cells are more voluminous in size and less flattened, and in most of them the fibrils appear much larger on cross section, and are more irregular in size and distribution: this relation is to be seen from the carefully drawn Fig. 25, Pl. 2, and Fig. 42, Pl. 3. Here there is frequently a grouping of the fibrils into pairs, sometimes several are so closely apposed as to form one large one, and the fibrils often appear ribbon-shaped rather than rounded. Thus the structure of the muscle elements in the median line is different from that of those elsewhere on the body wall, the principal difference being the greater volume of the cell and the smaller number but larger size and more irregular distribution of the contractile fibrils. Now in death the worm generally contracts so as to bend ventrad, due certainly to the ventral musculature having a greater power of contraction; perhaps this is due again to the larger size of the fibrils of these cells, or perhaps the larger size of these fibrils is due to their greater degree of contraction.

No transverse striation of the muscle cells could be found on longitudinal sections.

The muscle cells are not branched, and by proper use of the iron-haematoxylin stain the muscle cells can be sharply differentiated from the intermuscular substance. The latter is found in the greater region of the trunk, it separates the muscle cells from each other and surrounds each of them on all sides. It is a dense substance (*I.M.S* Fig. 25, Pl. 2; Figs. 37, 42, Pl. 3) of a different chemical nature from the contractile zone of the muscle cells, and contains sparsely vacuoles with deep-staining rounded bodies in them, perhaps degenerated nuclei. The septa made by this substance between the muscle cells are very regular in diameter (Fig. 37, Pl. 3), while the diameter of the muscle cells on a given plane of a cross section is very variable. Except with suitable staining it is very difficult to distinguish between the clear cores of the muscle cells and this intermuscular substance. The latter shows the characteristic of the parenchym in having vacuolar cell bodies with a large amount of dense intercellular substance; but whether it is a degenerate parenchym layer, or is a product of the muscle cells, cannot well be determined in the adult stage. In the anterior trunk region (Fig. 14, Pl. 1), as in the posterior ends of the tail lobes (Fig. 71, Pl. 5), and in the mid-ventral region of the whole trunk, the ordinary parenchym (*Par*) of the body envelopes the muscle cells.

In the anterior region of the trunk, a little behind the brain, muscle cells radiate from the body wall inward through the large-celled parenchym, and terminate in this parenchym layer at varying distances from the wall of the stomach (*R. Musc* Figs. 2, 14, Pl. 1). There is thus present here an irregular muscle diaphragm; but its structure varies in different individuals; sometimes the muscle fibres which compose it come from the lateral aspects of the body wall, in others from the dorsal also and even from the ventral (in the latter case they pass obliquely upwards around the nerve cord). The function of these radial fibres is obviously by their contraction to enlarge the cavity of the stomach, making the latter a sucking or pumping organ.

No other muscle cells were found that those described, thus there is no special musculature of the internal organs, and no trace of a transverse musculature was found in the body wall.

B. In the Male.

The finer structure of the muscle cells is as in the female, and the arrangement of the muscular layer is also in general the same, except that on the lateral walls of the trunk (Fig. 83, Pl. 6, Figs. 84, 88, Pl. 7) the cells are flatter and higher, and in the medio-ventral line the muscle layer is more deflected upwards around the sides of the neural lamella, corresponding to the greater height of the latter in the male. Differences are also noticed in the posterior region of the body, in accordance with the difference of structure in this region in the male. In the tail lobes the muscle cells are largest and most numerous dorsally and laterally (*Musc* Fig. 85, Pl. 7), smaller and more scattered on the median side (next the thickened sensory hypodermis). Only the dorsal and lateral cells extend to the posterior ends of the lobes; the contraction of such muscles obviously tends to elevate and separate the ends of the tail lobes. The more dorsal of the smaller cylindrical cells of the median surface of each lobe extend forward as far as the vertical portion of the cloaca, and end in the parenchym on the sides of this portion of the cloaca (*Musc* Fig. 86, Pl. 7); their contraction would tend to pull the cloaca backwards. The more ventral muscle cells of the median surface of each tail lobe extend forwards to form a muscular mantle on the dorsal and median surface of each tail nerve, at the plane where the neural lamellae of these nerves join with each other at their points of attachment to the hypodermis. Obviously these disarrangements of the muscular layer in this posterior region of the body are due to the ingrowing of the cloaca and of the caudal nerves from the hypodermis.

There is thus no vertical muscular diaphragm in the male connecting the posterior end of the cloaca with the dorsal body wall, as has been described for the genus *Gordius*.

Literature on the musculature. Vejdovský (1886) first discovered the nuclei of the muscle cells. He described the muscle cells of *Gordius*, especially of the male, as branched; but an examination of his figures on this point shows that he probably confuses the network of intermuscular substance with the muscle cells themselves; this explains why in one species he describes the nucleus as lying on the outer side of the cell, and why he denies the occurrence of an intermuscular substance; this appears very plain from his fig. 48. In his later paper (1894) be brings observations to slow that what I have called "intermuscular substance", probably arises from the muscle cells. Villot (1887) notices the intermuscular substance, which he states to be the result of the fusion of the walls of the embryonic cells which give rise to the muscle elements; he denies the occurrence of muscle nuclei in the adult stage; and notes finding in the embryonic stages forms of muscle cells similar to those of Nematodes. Camerano (1888a) concludes the muscle elements are of the nematodan type. Rohde (1892) quite closely confirms Vejdovský's account; he distinguishes a "Rindenschicht" which contains the "Muskelsäulchen", and an axial "Marksubstanz" containing the nucleus; he finds the muscle cell often open on its inner surface, and so concludes that it is of the nematodan type. None of these writers could find the mode of innervation of the musculature; and all but Vejdovský maintain that the muscles are of the type found in Nematoda.

V. The Intestine.

In regard to the alimentary tract *Paragordius* shows few differences from *Gordius*, and since the latter has been well described in regard to this structure, only a brief account need be given here.

In the adult stage the whole intestine appears very degenerate in comparison with the preceding parasitic stage, the nuclei and cytoplasm katalytically modified, and the cells much smaller; further, in no adult individual was any trace of food substance to be seen in it, so that these worms probably take no nourishment in the adult, aquatic stage.

The mouth opening is a small longitudinal split, placed at the anterior end of the head, in the male usually nearly terminal (*Mo* Figs. 1, 3, Pl. 1), in the female subterminal or more nearly ventral (*Mo* Fig. 2). The hypodermal cuticula is thickened at the mouth aperture, and there forms a rounded projection directed inwards (Fig. 1), its axis a hollow tube and not closed; this cuticular thickening seems to be more pronounced in the male. The anterior region of the intestine from the mouth opening to just behind the brain may be termed the oesophagus (*Oes* Figs. 2, 3); it is the narrowest portion of the intestine, lined by rather cubical cells (*Oes* Fig. 13, Pl. 1; Figs. 15—17, Pl. 2), and externally surrounded on all sides by the parenchym (*Par*) of the head region. Behind the brain there is a considerable dilatation of the intestine, which, since it stands in immediate connection with the radiating fibres of the muscular diaphragm (described with the musculature), may be regarded as a sucking or pumping stomach (*Stom* Fig. 14, Pl. 1). Through the greater region of the trunk is found what may be termed the middle intestine (*Int* Figs. 61, 63, 64, Pl. 4; Figs. 65, 66, 68, 70, Pl. 5), a ventral tube lying above the nerve cord in the medio-ventral body cavity, and extending backwards nearly to the cloaca. This portion is composed of an irregularly folded, cubical epithelium, with large nuclei whose long axes are parallel to the long axis of the intestine; the cells appear for the most part highly degenerate (*Int* Fig. 21, Pl. 2). Bounding this epithelium is a layer of a denser and more homogeneous substance (*Int. S*), without nuclei, with short radial projections; it cannot be determined from the adult condition whether this is a true basement membrane (a formation of the epithelial cells themselves), or e. g. a modified parenchym layer, but the absence of nuclei would speak for the former view. In this region of the body the intestine is ventrally attached to the parenchym lining of the nerve cord. At the posterior end of the female (Figs. 66, 68, Pl. 5), the receptaculum seminis (*Rec*) lies immediately above the nerve cord (*N. C*) and here forces the intestine (*Int*) out of its original position, so that the latter comes to lie variously either upon the side of or above the receptaculum. In the female, from this nearly axial position the intestine passes straight backwards to the dorsal side of the atrium (*Atr* Fig. 74, Pl. 5), there becomes imbedded in the small-celled parenchym sheath (*S. Par*) of the atrium, and finally opens into the lumen of the posterior end of the atrium, or in other words, the anterior end of the cloaca. This most posterior region of the intestine (*P. Int* Fig. 74, Pl. 5) is lined by cells which have the character of those of the most anterior region of the cloaca, and may be termed the posterior intestine.

In the male the intestine (*Int* Fig. 83, Pl. 6; Figs. 84, 88, 90, Pl. 7) has much the same structural relations as in the female. Posteriorly (Fig. 81, Pl. 6) it joins with the laterally placed vasa deferentia (*Vas*) at the anterior end of the cloaca (*Cl*).

The cloaca will be described with the genital organs.

Literature on the intestine. Vejdovský (1886) described this organ as consisting of the mouth, the mouth cavity and pharynx, the intestine and its aperture; the mouth in *Gordius tolosanus* is closed by a chitinous plate; in *G. preslii* there is frequently no closure of the mouth. Besides the epithelial lining of the intestine he distinguished an outer "Cuticularschicht, die stellenweise höckerartige Verdickungen bildet". Villot (1874) states that there is neither mouth nor oesophagus in the adult stage; the intestine (1887) consists of a "conjunctive" envelope, a fibrous layer, and an endothelium, and its diameter is very much shrunken in the adult stage. Camerano (1897b) states that the mouth opening is generally atrophied in the adult. von Linstow (1889) finds that the mouth is atrophied in the adult stage of *Gordius tolosanus.*

VI. The Nervous System.

The central nervous system consists of the ventral unpaired nerve cord, with the cephalic ganglion as its anterior enlargement and the caudal or cloacal ganglion as its posterior enlargement; at least the anterior portion of the caudal nerves in the male must also be regarded as a direct continuation of the nerve cord, and hence as belonging to the central nervous system. To the peripheral nervous system belong the neural lamella; the endings in the hypodermis of the fibres of nerve cells situated in the central nervous system; the hypodermal longitudinal nerve; sensory cells placed in the hypodermis which send their fibres towards the central nervous system; non-sensory nerve cells placed in the hypodermis; and the nerves (nerve fibre bundles) which innervate the cloaca in the female, and the vasa deferentia in the male. The following description is based upon the female, unless there is a statement to the contrary.

A. The ventral Nerve Cord.

This lies (*N. C* Fig. 14, Pl. 1; Figs. 61, 63, 64, Pl. 4; Figs. 65, 66, 68, 70, 73—75, Pl. [5) in the medio-ventral line of the body, below the intestine (*Int*) and separated from it by a layer of small-celled parenchym (a deflection of the walls of the mesenteries), elevated a short distance above the musculature (*Musc*) of the body wall and attached to the hypodermis by a median band, which will be called the neural lamella (*N. L*).

One adult female fixed in 4 % formaline was cut into short pieces and all of these imbedded in paraffine; a series of sections of $6^2/_3$ μ thickness covering at least two slides, was cut of the greater number of each of these pieces, so that the relations of the nervous system might be studied in the various regions of the body without the necessity of the great labor of sectioning an entire individual. This fixation is most excellent for the nervous elements. Series of sections of other individuals, fixed in various other fluids were also studied as a control. The iron-haematoxylin method of staining proved most satisfactory for the determination of the details; for the study of the chromophobic nerve cells a rather darker stain is necessary, for the chromophilic cells a fainter stain; in general the destaining should proceed until the cytoplasm of the hypodermis has given up its stain almost entirely.

Two main elements may be distinguished in the nerve cord: chromophilic nerve cells and chromophilic nerve fibres, and chromophobic nerve cells and chromophobic nerve fibres, the former being those which unite most strongly with the iron-haematoxylin stain, the latter those which unite with it less strongly.

The chromophobic elements. The chromophobic nerve cells (*Chb. C* Figs. 22, 24, 25, Pl. 2; Figs. 26, 31, 32, Pl. 3) lie on the ventral and lateral aspects of the nerve cord, and in only one or two sections out of the hundreds carefully studied were any found upon the dorsal side. On the lateral aspects they form for the most part a single layer, while ventrally they may be from two to four or five deep. They are characterized by a regularly spherical or oval nucleus (*N* Figs. 29, 30, Pl. 3), with one true nucleolus and very little chromatin arranged in a delicate reticulum so that they stain faintly. Their cytoplasm appears very finely granular, is nearly homogeneous only occassionally somewhat vacuolar, and appears to contain neither centrosomes nor attraction spheres. These cells on the lateral aspects of the cord are comparatively uniform in size and small. But on the ventral aspect are found two varieties of these cells: small ones similar to those on the lateral aspect, and much larger giant cells (Fig. 24, Pl. 2; Figs. 26, 31, Pl. 3). These giant cells are much less numerous than the others: in 406 sections from different regions of the body, from 39 to 53 of these cells were found; that is, certainly 39 were present, while the remainder may not have been sectioned so as to show their full diameters, or might have been intermediate in size between the giant cells and the small cells. Four or five was the greatest number found in any twenty consecutive sections. Sometimes a paired arrangement of these cells occurs, but they generally are not paired and are placed irregularly one behind the other (some in the median line, some to the right or left of this line).

As far as can be determined from an examination of them as seen on sections, these giant cells appear to be bipolar with two large processes .proceeding from that surface of the cell directed towards the fibrous core of the nerve cord; this is to be clearly seen on two cells of the Figs. 24, 26; in the cases where only one process is seen it is then probable that the other process lies out of the plane of the section. Many of the smaller type of chromophobic nerve cells appear to be bipolar or even multipolar (Figs. 29, 30, Pl. 3), but it is difficult to determine their exact form since all fixatives cause more less shrinkage in these cells, so that their outlines appear generally irregular. All these cells are membraneless.

The processes of these cells constitute the chromophobic nerve fibres of the nerve cord; in the Figs. 22, 24, 25, Pl. 2; Fig. 26, Pl. 3 these are shown of a lighter color than those of the chromophilic nerve cells. These chromophobic fibres can only be clearly seen on the thinnest sections when deeply stained with iron-haematoxylin. Within the nerve cord I have not been able to follow the course of a single fibre for more than a very short distance, and so could not determine whether they ramify. On cross section they appear larger than the chromophilic fibres as a rule, and several often appear to fuse together (which is probably due to the action of the fixatives).

These chromophobic nerve elements probably are motor and visceral in their function, as will be shown in the description of the peripheral nervous system.

The chromophilic elements. These are characterized by their deep-staining quality, and with the usual methods of staining are the only elements to be seen clearly (the sharply pronounced elements of Figs. 22, 24, 25, Pl. 2; Fig. 26, Pl. 3). The nucleus always stains intensely and is rich in chromatin (*Chl. N*); these nu are generally flattened and much twisted, so as to resemble mu crumpled and wrinkled leaves, very different from the evenly outli nuclei of the chromophobic nerve cells. The cell is multipolar, a stains intensely black with iron-haematoxylin. There is around t nucleus no noticeably thickened cytoplasmic enlargement, but from th region long branching processes pass into the fibrous core of t nerve cord and into the neural lamella. These processes are e ceedingly long, dense and smooth in contour, and are as clear marked as lines of ink upon the preparations. The Figs. 22, 24, 2 Pl. 2; Fig. 26, Pl. 3 where these cells and their fibres have bee carefully drawn with the camera lucida show these relations bette than any description. Whether the branching fibres of one cell inter lace with those of others or anastomose with them, could not b determined. These cells are fewer in number than the chromophobi cells, and their nuclei are for the most part ventrally situated; where transverse fibre commissures (Fig. 26 *N. C. Com*) occur the nuclei are also found upon the dorso-lateral margins of the cord. The greater part of the substance of the nerve cord is constituted by their ramifying fibres.

These cells would appear at first sight to be similar to the multipolar neuroglia elements of certain other Invertebrates, such as the Nemerteans, that is, to be the supporting elements of the nervous system. But it will be shown that their processes pass through the neural lamella into the hypodermis and there stand in connection with sensory elements, so that they must be ascribed a sensory function in addition to one of mere support.

The fibre tracts. On first examination the ventral cord appears to be tripartite, composed of three rays converging to the point of the neural lamella. But a closer examination shows that each lateral ray is made up of several distinct fibre tracts, so that the following regions may be distinguished after a careful comparative study of the cord on transverse and longitudinal sections:

1) The median tract (*M. T* Figs. 22, 24, 25, Pl. 2; Figs. 26, 32, Pl. 3), the largest, extending from the ventral to the dorsal margin of the nerve cord, and bounded on either side by chromophilic nerve fibres which course vertically. This tract is made up mainly of longitudinally directed chromophilic fibres, which are here more closely arranged than elsewhere in the cord. Only very rarely

are nerve cells found on the dorsal side of this tract, while they are most abundant at its ventro-lateral angles.

2) On each side of the preceding is a lateral tract, which shows three not very sharply demarcated subdivisions: a) a dorsal tract (*D. T* Figs. 22, 24, Pl. 2; Fig. 26, Pl. 3) composed mainly of chromophobic fibres, which are here more densely grouped than elsewhere in the cord; this is also the smallest tract. b) A latero-ventral tract (*L. V. T* Figs. 22, 24, 26, Pl. 3) which is bounded peripherally by the lateral layer of chromophobic nerve cells; this is composed mainly of longitudinally coursing chromophilic fibres. c) A medio-ventral tract (*M. V. T* Figs. 22, 24, 26), larger than the preceding and placed between it and the median tract; it contains chromophilic fibres coursing in all directions but mainly longitudinally, and chromophobic nerve fibres; the nerve fibres are generally less abundant in this tract than in any of the others.

Horizontal longitudinal sections (Fig. 32, Pl. 3) of the nerve cord show: the median tract (*M. T*) with longitudinally directed fibres; on each side of this a tract with finer chromophilic fibres and with more numerous chromophobic fibres, the medio-ventral tract (*M. V. T*), which appears the least deeply stained of all the tracts on account of its having the fewest fibres; on the outer side of each of the latter tracts the latero-ventral tracts (*L. V. T*), with large chromophilic fibres running longitudinally; and outermost on the sides of the nerve cord the nerve cell layer (chromophobic nerve cells, *Chb. C*).

The nerve cells being on the periphery of the cord send their fibres radially inwards. The "dotted substance" (Punktsubstanz, Leydig) of the central nervous system is thus not a network of fibres nor a nuclear reticulum, but is composed of the fibres of two kinds of nerve cells. The chromophobic nerve cells seem to lie in clear areas since the chromophilic fibres are least numerous around them. The nerve cord has no peripheral envelope (no neurilemma) of its own, but is immediately invested by the small-celled parenchym; external to the peripheral layer of nerve cells is a sheet of chromophilic fibres.

Transverse commissures. At intervals along the nerve cord are found transverse commissures of fibres (both chromophobic and chromophilic), extending from the dorso-lateral angle of one side to that of the other (*N. C. Com* Fig. 26, Pl. 3); the cells from which most of these fibres arise are placed at the corresponding angles of the cord. The distances between these commissures as determined on a series of sections of the anterior trunk region were found to be as follows: 80, 90, 50, 170, 20, 20, 40, 50, 20 μ; and in another individual, in a region a little more posterior: 40, 60, 33, 26, 60, 40, 40, 33, 20, $6^2/_3$, 40, 20, 46, 13, 40 μ. Thus such commissures are very numerous and not separated by regular distances.

In the nerve cord there is no segmental grouping of the nerve cells of either type so far as could be determined, and certainly no regular ganglionic arrangements of them. The transverse commissures also are too close together and too irregularly disposed to be regarded as metameric.

B. The Cephalic Ganglion.

The anterior end of the nerve cord is slightly enlarged (*N. C* Figs. 2, 3, Pl. 1), more thickened from side to side than it is dorsoventrally; this anterior enlargement may be called the cephalic ganglion (see also Fig. 6, Pl. 1; Figs. 16 and 17, Pl. 2, *Ceph. G*). It is not sharply demarcated from the nerve cord, and its posterior beginning may be said to be at that point where there cease to be nerve cells placed on the lateral aspects of the cord (about the plane of the posterior end of the eye capsule in the female, Fig. 2, Pl. 1).

In the cephalic ganglion the nerve cells are numerous but limited to the median line, and extend forward as far as the plane where the cephalic nerves (*Ceph. N* Fig. 7) separate from each other. Thus in the head the fibre tracts appear to consist mainly of a large one on each side of the mid line, anteriorly the median fibre tract diminishing as the nerve cell layer becomes higher. About 187 μ from the most anterior end of the head the two lateral fibre tracts diverge from each other, the nerve cells ending also at this point; the separated fibre tracts, which may be called the cephalic nerves (*Ceph. N* Figs. 2, 3, 7), pass forwards and slightly dorsad, and terminate in the heightened hypodermis as will be described later; in them are no chromophobic nerve cells. The posterior portions of these nerves are separated from the hypodermis by a layer of parenchym, and upon their dorsal and median surfaces there is a sheath formed of the tissue of the eye capsule (*E. Cap* Fig. 13). The parenchym layer which separates the posterior portion of each cephalic nerve from the hypodermis is interrupted at two points, one 127 μ and the other about 153 μ from the anterior end of the head; at each of these points a branch nerve passes ventrad from the cephalic nerve to connect with the hypodermis; these small nerves may be termed the ventral nerves of the head, and of them the more anterior is the larger. They are symmetrically arranged on the two sides of the body (*N.2* Fig. 2, Pl. 1; Fig. 15, Pl. 2).

At the plane where the cephalic nerves meet together a transverse fibrous commissure (Fig. 23, Pl. 2) joins them lying close to the ventral surface of the parenchym sheath (*Par*) of the oesophagus (*Oes*), and this may be called the ventral commissure of the cephalic ganglion. This commissure (*V. Com* Figs. 16, 23), which is composed entirely of nerve fibres, sends its fibres dorsad around the sides of the intestine, and as a pair of large fibrous trunks these penetrate the tissue of the capsule of the eye, and there ramify as will be described in another place; these may be termed the dorsal nerves (*Dors. N* Figs. 2, 3, 6, 7, Pl. 1; Fig. 16, Pl. 2) of the cephalic ganglion, and together are probably comparable to the dorsal fibre commissure of other Gordiacea, but modified by the presence of the huge eye; there appears to be no direct commissure above the intestine uniting these nerves.

The nerve cells (chromophobic cells) of the cephalic ganglion extend as far forward as the point of separation of the two cephalic nerves; this most anterior portion of the nerve cell mass is also the widest from side to side, and the narrowest dorso-ventrally. There is thus a wide bridge of chromophobic nerve cells (Fig. 15, Pl. 2) connecting the roots of the cephalic nerves (*Ceph. N*), this bridge of nerve cells being separated from the intestine above as well as from the hypodermis below by parenchym. At the plane of the ventral commissure (Fig. 23, Pl. 2) the nerve cell mass (*Chb. C*) has a dorso-ventral thickness equal to that of the fibrous tracts (roots of the cephalic nerves) on either side of it; but behind this commissure the fibre tracts come to meet over the mass of nerve cells, so that the latter more posteriorly become restricted to the medio-ventral region.

Thus the cephalic ganglion of *Paragordius* is the but little modified anterior termination of the nerve cord. Anteriorly it bifurcates (Fig. 7, Pl. 1), the forks being the forward continuations of the lateral fibre tracts, the median fibre tract not being represented at this anterior region. Each such cephalic nerve (*Ceph. N*) terminates anteriorly against the hypodermis of the ventro-lateral surface of the hypodermis; and from the ventral side of the more posterior part of the each cephalic nerve two smaller ventral nerves pass to the hypodermis. There is one transverse fibrous commissure below the oesophagus, and from this commissure two large nerves, the dorsal nerves, pass dorsad on each side of the oesophagus into the tissue of the eye sheath, but apparently do not form a ring commissure above the intestine nor in the eye sheath. No chromophobic cells lie above the ventral commissure, which is composed of fibres exclusively, and few or no chromophilic nerve cells. Hence there is no supra-oesophageal ganglion present, i. e. no brain in the strict morphological sense, the cephalic ganglion being altogether infra-oesophageal. This cephalic ganglion is therefore of a very simple type.

In a male individual which was carefully examined the cephalic ganglion (Fig. 3, Pl. 1) showed essentially the same structure as in the female, though there were a few differences as follows: the ganglion is dorso-ventrally thicker than the nerve cord; each cephalic nerve (*Ceph. N*) subdivides at its anterior end into three branches the most posterior of which is the smallest; and each cephalic nerve gives off three ventral nerves (*N. 2*) to the hypodermis.

The elements of the cephalic ganglion are the same as those in the nerve cord, chromophilic nerve cells and their fibres, and chromophobic cells and their fibres. Apparently these cells have the same form and structure as those of the cord. A count of the number of the giant chromophobic cells in the ganglion of a female showed: 14—16 on the left, 7—11 in the median line, and 7—13 on the right, a total of from 28 to 40 in all; these giant cells showed an irregular distribution.

C. The Cloacal Ganglion of the Female.

The cloacal ganglion is the enlarged posterior end of the ventral nerve cord, and is placed in the mid-ventral line just anterior to the point of bifurcation of the lateral tail lobes (*Cl. G* Fig. 72, Pl. 5). It is connected ventrally (Fig. 36, Pl. 3) by the here broadened neural lamella with the hypodermis (*Hyp*) of the body wall, and dorsally it is in direct contact with the epithelium of the cloaca (*Cl. Epi*). It may be said to commence anteriorly where it first comes into contact with the cloacal wall, and has a length of about 120 μ. At its middle point it is ovoid on cross section, widest dorsally, and here bulges upward the wall of the cloaca (Fig. 72, Pl. 5); at its posterior termination it is narrowly compressed laterally. It is thus fitted into the angle made by the junction of the lateral tail lobes.

From it arise nerves, the anterior cloacal nerves, which course forwards in the wall of the cloaca; and the posterior cloacal nerves, which course backwards (caudad) within the wall of the cloacal lining of the lateral tail lobes.

Anterior nerves. In one individual the arrangement of these was as follows: From the dorsal anterior edge of the ganglion arise two pairs of nerves, the more median much the larger and close together. As each of these continues cephalad it subdivides into smaller nerves, all continuing within the cloacal epithelium close to its basement membrane; these become anteriorly more numerous and smaller, and, as in the other individuals, cannot be followed as far forward as the anterior end of the cloaca. In another individual there are two or three pairs of these anterior nerves; in a third, two pairs as in the first; in a fourth individual, two pairs, of which the middle pair are united together in the middle line for a considerable distance, but separate anteriorly. Thus there is some individual variation in the exact arrangement of these nerves.

Posterior nerves. These (*P. Cl. N* Fig. 36, Pl. 3) arise from the dorsal margin, some from the dorso-anterior, others from the dorso-posterior margin, and course caudad within the cloacal epithelium of the lateral tail lobes; none were seen in the dorsal tail lobe; they lie in the cloacal epithelium close to its basement membrane, and cause outward projections of the latter. In one individual there were, close to the ganglion, 1 to 2 on the left side and 4 on the right; further caudad their number increases, apparently by ramification, and they become smaller, until from 10—12 in the right and 8—9 in the left lobe can be distinguished. Some of these could be followed quite to the end of the tail lobes. Their diameters vary on successive sections probably owing to unequal pressure on the part of the cloacal cells, and they shift their positions, even apparently anastomosing posteriorly, and the more lateral of them ascend within the cloacal epithelium to about half way between the dorsal and ventral side of the cloaca. In another individual they were less numerous, so that they not only vary in different individuals, but also do not show a strictly symmetrical grouping in the same one.

Structure of the ganglion (Fig. 36, Pl. 3). The anterior end of the ganglion is structurally similar to the ventral nerve cord, of which it is only a specialisation, but more posteriorly the chromophobic nerve cells (*Chb. C*) become more numerous and are arranged mainly in its dorsal half and along its dorsal margin. These cells are like those of the nerve cord, except that no giant cells occur in the ganglion. The chromophobic cells (*Chl. C*) are less numerous than in the nerve cord, but have the same relative position as in the latter, i. e. near the insertion of the neural lamella. The chromophobic fibres are numerous in the ganglion; the only transverse nerve fibre commissure is placed close to the anterior end of the ganglion; the chromophilic fibres are less numerous than in the nerve cord, some of them running longitudinally, others radiating upwards from the medio-ventral side of the ganglion. The relation of the nerve fibres to the cloacal nerves and to the hypodermis will be described below.

D. The Cloacal Ganglion of the Male.

The cloacal ganglion (*Cl. G* Fig. 80, Pl. 6; Figs. 87, 89, Pl. 7) is not so sharply delimited as it is in the female, and represents only a slightly enlarged terminal portion of the ventral nerve cord. It extends from the point of bifurcation of the tail nerves (*Cd. N* Fig. 81, Pl. 6, just anterior to the vertical portion of the cloaca) behind, to the plane where nerves leave its dorsal surface to connect with the vasa deferentia in front (Fig. 89, Pl. 7); the length of the ganglion varies in different individuals of the same size, from about 107 μ to 180 μ. In two males it was higher than wide at its anterior end, in another male it was wider than high throughout its course on account of the cloaca being pressed down upon it; it is widest and lowest posteriorly. Its boundaries are not so clearly marked as in the female, since it is not so enlarged, and remains through its entire length separated from the cloaca by a parenchym layer. It differs from the corresponding ganglion of the female also in containing giant nerve cells, in having no chromophobic cells situated in its dorsal half, and in that its neural lamella is very low and broad posteriorly. Thus in the male the cloacal ganglion is not so sharply differentiated from the rest of the ventral nerve cord as in the female.

From the dorso-lateral angles of its anterior end (Fig. 89) small bundles of nerve fibres (*Gen. N*) pass vertically to the vasa deferentia (*Vas*) placed just above, and near the anterior ends of the latter. On each side of the ganglion for a longitudinal extent of about 60 μ such fibres pass to the vasa; it could not be determinated how these nerve fibres terminate in the vasa. These small nerve bundles contain some chromophilic fibres but apparently (though this point could not be positively determined) they are composed mainly of chromophobic fibres. It is possible that some of these fibres may innervate the intestinal wall (*Int*) which lies between the vasa at this point. The fibrous sheaths (*Vas. S*) of the vasa deferentia are here composed of dense, deep-staining concentrically arranged spindle-shaped cells, apparently a modified parenchym and very similar to that of the sheath of the eye, and a thin layer of this tissue extends between the vasa to form a thin lining to the dorsal wall of the ganglion, here separating the ganglion from the parenchym (*Par*) which envelopes it at all other points. These small nerves which innervate the vasa deferentia may be called the genital nerves.

Just anterior to the vertical arm of the cloaca the ganglion divides into a right and a left caudal nerve (*Cd.N* Fig. 81, Pl. 6). Each of these courses caudad within the caudal lobe of its side of the body, and is situated medio-ventrally close to the thickened portion of the hypodermis of the tail lobe (*Cd.N* Fig. 85, Pl. 7). These nerves may be traced to the posterior ends of the lobes, and each becomes most posteriorly a thin nervous sheet on the median side of the tail lobe (Fig. 43, Pl. 3); their relations to the hypodermis will be described later.

These are the only nerves arising from the ganglion in the male.

The finer structure of the ganglion (Fig. 89, Pl. 7) is very similar to that of the ventral cord. The chromophobic nerve cells (*Chb. C*) are placed medio-ventrally and laterally on the periphery of the ganglion, but are two or three layers deep on the sides. Giant cells occur medio-ventrally, and in one individual at least ten of these were counted. The chromophobic cells do not extend into the caudal nerves. The chromophilic cells are placed ventrally. Their fibres radiate upwards and outwards from the region of the neural lamella, and also longitudinally, but are not so numerous as in the nerve cord; they produce a narrow transverse commissure at the point of bifurcation of the caudal nerves, and another at the anterior end of the ganglion (this one corresponding to the only one of the female). Most of the nerve fibres of the ganglion are chromophobic fibres.

E. The Neural Lamella.

In both sexes from the cephalic ganglion to the posterior end of the cloacal ganglion the ventral nerve cord is attached to the hypodermis by a median unpaired lamella, the neural lamella (*N.L* Figs. 2, 3, 14, Pl. 1; Figs. 22, 24, Pl. 2; Fig. 26, Pl. 3; Pl. 7). In all these regions this lamella appears to be continuous and not interrupted nor segmented; at least no such interruptions were seen in any region of the body, and on longitudinal sections (Figs. 2, 3, Pl. 1; Figs. 31, 33, Pl. 3) as well as upon dissected specimens it seems perfectly continuous. Thus the lamella attaches the nerve cord to the hypodermis, from which the nerve cord had split off; and the lamella is therefore in origin a hypodermal structure. This lamella is a thin vertical plate (*N. L* Figs. 22, 24, 25, Pl. 2; Fig. 26, Pl. 3), bounded on either side by parenchym cells, and containing a clear substance with vertical nerve fibres, at least the greater part of which come from cells placed in the central nervous system, and which course into the hypodermis. This is the only path for nerve fibres to the hypodermis.

Horizontal longitudinal sections of the lamella close to its attachment with the hypodermis (Fig. 33, Pl. 3), show very clearly that the chromophilic nerve fibres (*Chl. F*) contained in it are not paired, but for the most part placed in a close row one behind the other; cross sections (Figs. 22, 24, 25, Pl. 2; Fig. 26, Pl. 3) sometimes show two nerves one on the right and on one the left, but this is probably due to two successive nerves being shown in the same obliquely cut section. Very frequently the nerve fibres within the lamella appear to be spirally twisted in their course; this might be produced by a shortening of the lamella, either normally or by the action of fixatives.

In the head region this neural lamella is modified. In one female, as seen in the median reconstruction of the head (Fig. 2, Pl. 1), the unpaired neural lamella of the nerve cord extends forwards about as far as the cephalic ganglion, and there ends. In front of this are several slender non-connected septa (*N. Septa.*), some paired and others unpaired, which connect the cephalic ganglion with the hypodermis; on the reconstruction the paired ones are represented in white, the unpaired ones in a dark color; and on the cross section, Fig. 15, Pl. 2, one of the septa of the most anterior pair is shown. In a male the arrangement of these septa (*N. Sept*) was somewhat different, as shown in another median reconstruction (Fig. 3, Pl. 1); where the unpaired septa are shown in dark shading and the paired in light shading. The neural lamella is thus not a continuous median structure below the cephalic ganglion, as it is below the ventral nerve cord. This fact might indicate that the cephalic ganglion may be more or less segmental in its mode of origin from the hypodermis, that the nerve cells (neuroblasts) may delaminate from the hypodermis at several points instead of along one continuous line. But it is more probable that the interruptions of the lamella are here produced by the excessive heightening of the hypodermal cells.

The cloacal ganglion of the female (Fig. 36, Pl. 3) lies ventrally and just anterior to the point of bifurcation of the lateral tail lobes;

the neural lamella is here continuous and connects the ganglion with the hypodermis below and behind it.

The lamella is also continuous below the ganglion of the male (*Cl. G* Figs. 87, 89, Pl. 7), but since in this sex the cloacal ganglion bifurcates posteriorly to form the two caudal nerves, its neural lamella also bifurcates, so that each caudal nerve in its anterior portion has its own neural lamella, connecting it with the hypodermis (Fig. 86, Pl. 7). The neural lamella decreases in height as the nerve passes further caudad (Fig. 85), and finally disappears so that the nerve lies directly against the hypodermis (Fig. 43, Pl. 3; Fig. 46, Pl. 4). The posterior portions of these nerves have thus retained their primitive hypodermal connection.

F. The longitudinal Hypodermal Nerve.

The point of attachment of the neural lamella (*N. L* Figs. 22, 24, 25, Pl. 2; Fig. 26, Pl. 3) to the hypodermis is conical on cross section, the cytoplasm there appears clear and structureless, and in this clear space lie nerve fibres (*L. H. N*) which course longitudinally in the inner portion of the hypodermis in the medio-ventral line. This may be called the longitudinal nerve of the hypodermis. It is composed of nerve fibres alone, no nuclei occurring within it; the nerve fibres are from the chromophilic nerve cells situated within the ventral nerve cord. On cross sections these fibres appear as deep black granules lying in a clear substance. Whether chromophobic fibres also occur in this nerve could not be satisfactorily determined. As will be shown more fully later, nerve fibres from the nerve cord pass by means of the neural lamella into the hypodermis, there some of them enter into the constitution of the longitudinal nerve, while others turn off to the right and left to terminate in plexuses in the hypodermis. Since the number of nerve fibres found within the longitudinal nerve is always small on a given cross section, it is probable that such fibres course only short distances within the nerve and then leave it to end in the hypodermis.

The longitudinal hypodermal nerve is found as far as the neural lamella extends, that is also beneath the cloacal ganglion (*L. H. N* Fig. 36, Pl. 3), and in the male it posteriorly subdivides into two, accompanying the divisions of the neural lamella into the tail lobes.

G. The peripheral Nervous System of the Trunk.

The following description applies most particularly to the female, where these anatomical relations were more thoroughly examined than in the male. And first will be described the region of the body between the cephalic ganglion and the cloacal ganglion.

Chromophilic nerve fibres of the hypodermis. These (*Chl. F* Figs. 22, 24, 25, Pl. 2; Fig. 26, Pl. 3) are the processes of chromophilic nerve cells of the ventral cord, which enter the hypodermis (*Hyp*) by way of the neural lamella (*N. L*); and they appear to come mainly if not wholly from those cells which have a more ventral position in the nerve cord. On entering the hypodermis some of these bend and course longitudinally: these are the ones which compose the hypodermal longitudinal nerve already considered (*L. H. N*). The others on entering the hypodermis bend to the right and left and then course in the hypodermis along the sides of the body. These fibres, which appear very sharply marked on iron-haematoxylin staining as deep black threads in the much paler hypodermis, ramify at their ends, that is break into plexusus (Figs. 22, 25). In one case such a fibre was traced from the ventro-median line to a point about half way in the hypodermis between the dorsal and ventral side of the body before ramifying, but as a rule the fibres subdivide into plexuses in the ventral and ventro-lateral hypodermis (Figs. 27, 28, Pl. 3). Before ramifying they lie in the hypodermis close to its inner margin, and take in general a straight course. These fibres are smooth and dense and highly refractive. A comparatively small number of them show, close to the point of departure from the neural lamella, lenticular thickenings of the same refractive appearance as the remainder of the fibre (*Chl. F* Fig. 28); I could not determine the nature of these thickenings, beyond that they are not nuclei, and probably are not artefacts since they are found on only a small number of the fibres and after both alcohol and formalin fixation.

On entering the hypodermis and there turning to the right or left, these chromophilic nerve fibres run for a varying distance, then subdivide into plexuses. These plexuses become gradually indistinguishable from the cytoplasm of the hypodermal cells as they become smaller (Fig. 22, Pl. 2; Figs. 27, 37, Pl. 3). It could not be well determined whether these plexuses end in or around the hypodermal cells, since with the degree of destaining necessary to show the nerve fibres with sharpness the boundaries of the hypodermal cells cannot be distinguished: but in no case were special end knobs or varicosities seen as terminations of these plexuses. These fine terminal plexuses can be followed upwards in the hypodermis of the sides of the body, and more rarely can be seen even on the dorsal side. Apparently there are as many such plexuses as there are nerve fibres entering the hypodermis. In the most anterior region of the trunk, where the ventral hypodermis is particularly thickened, many of the chromophilic nerve fibres pass into the hypodermis directly from the neural lamella, and without first turning to the right or left, ramify in the hypodermis just beneath the neural lamella (Fig. 27, Pl. 3). So far as could be determined the whole of these plexuses lie within the hypodermis, and no evidence was found that branches are given off from them either into the cuticula without or into the musculature within. The finest end ramifications of the plexuses are in general placed nearer the outer than the inner border of the hypodermis. On account of the restriction of these chromophilic elements to the hypodermis, and in view of other evidence to be detailed below, it is very probable these elements are not motor but sensory.

The distribution and number of those chromophilic nerve fibres which on entering the hypodermis turn to the right or left was carefully plotted on a number of series of sections through various portions of the body of a large female. In 268 sections (each section of $6^2/_3$ μ thickness), 43 were found on the left side and 32 or 33 on the right. In each case the nerve was counted by considering only the point of its bending within the hypodermis, so as to exclude the possibility of counting separate parts of one nerve as different nerves. The largest number found on any twenty consecutive sections was 13, the smallest number, 3. These nerves are by no means regularly paired. Thus of the 75 or 76 nerve fibres entering into the above count, only 10 were paired in such a way that on the same cross section one would be found on the right and another on the left. In some cases as many as five succeed each other on one side of the hypodermis before one appears on the other side; sometimes right and left fibres alternate. In the anterior trunk region of another individual they were found to be somewhat more numerous and more regularly disposed; thus in one series of this region (sections in this case 10 μ thick) there were found in 61 consecutive sections, 40 nerve fibres on the left and 32 on the right; and in another series of 85 consecutive sections, 39 on the left and 41 on the right. In this series almost every section showed such a nerve fibre, and on some sections several could be seen on both sides of the mid line. There is accordingly no regular pairing of these nerve fibres, nor any regular arrangement of them beyond that they are placed close behind each other, that the number of them is approximately the same on the two sides of the body, and that in the anterior trunk region they are more numerous than in the posterior. The longitudinal vertical sections which show these nerves in the neural lamella before they have entered the hypodermis (Fig. 31, Pl. 3), as well as horizontal longitudinal sections of this lamella (Fig. 33), show that in the lamella also they are not regularly paired but for the most part are placed one behind the other.

Sensory nerve cells of the hypodermis. There are two main forms of these. The first are small, very irregular cells (*Sen. C* Figs. 22, 24, 25, Pl. 2), which with iron-haematoxylin stain intensely black, cytoplasm as deeply as the nucleus, while with DELAFIELD's haematoxylin the nucleus stains much deeper than those of the cuticular cells of the hypodermis. The nucleus is much smaller than that of the cuticular cells, and is generally very irregular in outline; and the cell body is still more irregular in form, and considerably smaller than that of the cuticular cells. Often the cell appears pyriform or irregularly elongated, thickest around the nucleus, and is in general bipolar. Peripherally an elongation extends towards the cuticula of the hypodermis, while from the opposite pole one or several delicate irregular processes arise and appear to break into delicate plexuses. In one case a process of such a cell could be followed to the base of the neural lamella (Fig. 22, right side). Such cells are probably sensory, since no other function can be well ascribed to them, and since their processes and plexuses seem to stand in an intimate relation to the chromophilic nerve elements of the hypodermis. In no case were any processes of them to be followed into the cuticula (and in fact in no region of the body could an innervation of the cuticula be determined). On account of their very irregular form they may be more or less degenerate in the adult condition. These cells appear to be very abundant in the hypodermis, especially on the sides of the body. With them must not be confused the degenerate gland cells, elsewhere described.

The second kind of sensory cells of the hypodermis are the elongated cuticular cells of the mid-ventral line (Fig. 13, Pl. 1; Figs. 15, 17, Pl. 2), which reach their greatest height in the head region and caudad from that point diminish gradually in size. These are modified cuticular cells, with deep-staining, rather elongate nuclei. They appear to be sensory, to show nervous connections only in the anterior region of the trunk, while the slightly heightened ventral hypodermis of the posterior trunk does not appear to be sensory; and in the anterior region the cells with nervous connections do not follow upon each other in an unbroken row, but are more or less separated into groups. On good iron-haematoxylin preparations of cross sections (Figs. 22, 25, Pl. 2; Figs. 27, 28, Pl. 3), chromophilic nerve fibres enter the hypodermis (*Hyp*) from the neural lamella and break into (apparently intracellular) plexuses in these sensory cuticular cells; such plexuses extend as far as the cuticle, and are apparently wholly the endings of chromophilic nerve fibres and not derivations of the sensory cells themselves. On account of this nervous connection they may well be considered sensory cells.

Cells of doubtful function. Small cells with very small, circular, rather faint-staining nuclei, found most abundantly in the hypodermis dorso-laterally (*x* Fig. 42, Pl. 3). The form and structure of the cell body could not be well determined. These are probably a modification of the chromophobic nerve cells.

Chromophobic nerve cells of the hypodermis. These (*Chb. C* Fig. 42, Pl. 3) are cells essentially similar in structure to the small chromophobic nerve cells of the central nervous system: there is a faint-staining rounded or oval nucleus, and a pale-staining, almost homogeneous cytoplasm. It is difficult to be sure of the form of these cells: sometimes they appear unipolar, sometimes bipolar (Fig. 39), and in some instances one or two long processes could be seen extending out from each of them. Each lies in a clear vacuole, close to the inner surface of the hypodermis, and their long axes are parallel to this surface.

The position of these and their number was plotted carefully on series of cross sections through various regions of an adult female. They are most numerous in the dorsally thickened region of the hypodermis, next numerous dorso-laterally, least numerous laterally and especially sparse in number ventrally. In the dorsal thickening of the hypodermis in 379 sections examined, each section being $6^2/_3$ μ thick, from 420 to 440 such cells were found; the greatest number found upon a given cross section was 4 or 5; the greatest number found in any 20 consecutive sections was 46, the smallest number, 8—10. They are scattered more or less evenly but with not noticeable regularity along the length of the dorsally thickened hypodermis, perhaps becoming less abundant posteriorly. They vary considerably in size, but none attain the volume of the giant cells of the nerve cord.

These nerve cells are most characteristic of the dorsal area of the hypodermis of the trunk.

Motor nerve elements. The chromophilic nerve cells of the central nervous system being apparently chiefly sensory in function, the chromophobic nerve cells, those of the central nervous system as well as those of the hypodermis, may be considered the motor and visceral elements. Within the central nervous system their processes, the chromophobic fibres, can be seen on suitably stained preparations, but it is very difficult to follow such pale-staining fibres to the periphery. When the hypodermis is destained sufficiently to show the chromophilic fibres sharply, the chromophobic fibres appear too pale to be easily seen. Yet it is not allowable to suppose that these chromophobic fibres are limited to the central nervous system, they must pass to the periphery, and in all probability by way of the neural lamella as do the chromophilic fibres. I have been unable to satisfactory determine the presence of chromophobic fibres within the neural lamella. But in the hypodermis along one of the chromophilic fibres which has entered it and there bent to one side, may frequently be seen a clear line of even diameter. Such clear lines may represent chromophobic nerve fibres which have penetrated into the hypodermis from the neural lamella. What would speak for this interpretation is the fact that within the nerve cord chromophobic and chromophilic nerve fibres are to be seen associated in pairs, so close is the connection that the larger chromophobic fibre sometimes appears to enclose the smaller chromophilic one (though the enclosure is probably an optical illusion). Now since the two kinds of nerve fibres are present together in the central nervous system, it is also probable that they pass into the hypodermis together. But with no stain, not even with thionin, could they be clearly seen in the hypodermis except as the clear lines above indicated. It is probable that the musculature of the body wall derives their innervation from such chromophobic nerve elements.

The chromophobic cells which occur in the hypodermis are structurally like those in the central nervous system. The course of their fibres could be followed, however, for only short distances. They lie very close to the musculature, and perhaps innervate it; or they may send processes into the mesenteries to innervate the genital organs.

H. The peripheral Nervous System of the Head.

As has been described earlier, the fibrous tracts of the cephalic ganglion diverge and passing anteriorly as the cephalic nerves (*Ceph. N* Figs. 2, 3, 7, Pl. 1; Fig. 17, Pl. 2) end against the hypodermis. The nerve endings in this hypodermis and the character of its cells can be best determined on longitudinal sections of the head stained with iron-haematoxylin (Fig. 6, Pl. 1; Figs. 34, 35, Pl. 3).

Anteriorly, laterally and ventrally the hypodermal cells are greatly elongated and are directed backwards (*Hyp* Figs. 1, 6, Pl. 1); certain of them form the anterior lining (*E. Hyp*) of the eye, and will be considered with that organ; the others and their nervous connections concern us at present.

In this hypodermis may be distinguished the following elements. 1) The cuticular cells of the hypodermis (Figs. 34, 35, Pl. 3), the largest elements and the most numerous, which are here longer than in any other region of the body, and directed backward at an acute angle from the cuticula. For some distance behind the head this backwards-pointing of these cells is to be seen. The nuclei (*Hyp. N*) of these cells lie generally quite close to the cuticula, where the cell body has its greatest diameter; more distally (internally) the cell body attenuates, becoming flattened and terminating as a fibre; the cytoplasm is quite vacuolar. 2) Smaller cells lying between the preceding, and generally with a deeper position within the hypodermis (Fig. 34). Their nuclei are also smaller and stain less deeply with iron-haematoxylin; generally the cell appears spindle-shaped like a long fibre with a middle dilation containing the nucleus; though distinctly bipolar, there sometimes appears to be more than one process going out from either end of the cell. In some cases it could be determined that the cell extended completely from the outer to the inner surface of the hypodermis. 3) Small rounded cells (*Chb. C.?* Fig. 35) with a very faintly-staining nucleus, very few in number and lying between the other cells; these may be small chromophobic nerve cells. 4) Fibres (*E. Cap. C* Fig. 34) from the tissue of the eye capsule, which will be considered elsewhere.

The nervous connections of these cells with the cephalic nerves are of several kinds (Fig. 35, Pl. 3). 1) The distal, fibrous terminations of the cuticular cells and those of the 2nd type of cells of the hypodermis are continued into the cephalic nerve (*Ceph. N*) of the corresponding side, though whether they course for any distance within the nerve could not be determined. These hypodermal cells are thus probably peripheral sensory elements, even though they also are the producers of the cuticle; it is to be noted that the cuticle over these cells is particularly thin, so that the whole surface beneath this thin cuticula might be especially adapted for touch sensations. The distal fibres of these cells cannot by staining be differentiated from the fibres of the chromophilic cells placed within the central nervous system. 2) Deep-staining fibres (*Chl. C* Fig. 35) of chromophilic cells placed within the cephalic ganglion and cephalic nerves. These appear to end between the hypodermal cells. The relations of these elements may best be seen on the Fig. 35.

The nervous connections in the paired and unpaired septa which connect the ventral surface of the cephalic ganglion with the hypodermis, appear to be the same as in the region just described.

It is to be noted that the hypodermis of the head region does not possess the small, irregular, deep-staining sensory elements which are to be found in the trunk region.

In the head region a certain number of the fibres of the chromophilic cells course between the parenchym cells (*L. Par* Fig. 35). The cephalic nerves when not in connection with the hypodermis, are bounded in part (especially dorsally and medially) by the capsule cells of the eye, in part by small parenchym cells.

I. The peripheral Nervous System at the posterior End of the Female.

The cloacal ganglion in the female (Fig. 36, Pl. 3; Fig. 72, Pl. 5) is in immediate contact with the cloacal epithelium (*Cl. Epi*), and processes of these elongated and bent cloacal cells (*Cl. Epi* Fig. 36, Pl. 3) penetrate for some distance into the dorsal surface of the ganglion, and even partially invest the more dorsal chromophobic nerve cells (*Chb. C*). Most of the chromophilic nerve fibres which have a vertical course in the ganglion pass into and end in the cloacal epithelium, lying just within the basement membrane of the latter, and some of these may be traced up the sides of the cloaca for some distance; but terminal plexuses of these fibres within the cloacal wall could not be determined. In one very clear case (Fig. 76, Pl. 6) it could be determined that a chromophobic fibre (*Chb. F*) accompanied a chromophilic one (*Chl. F*) into the cloacal wall; in this case the chromophobic fibre could be traced to the point where it bent at right angles to form a cloacal nerve (*Cl. N*), while the chromophilic fibre could be traced for only about half that distance. It is probable that such associations of these two kinds of fibres are general, but usually very difficult to determine. This particular fibre ran between the epithelial cells (*Cl. Epi*) of the cloaca.

The anterior and posterior cloacal nerves (*P. Cl. N* Fig. 36, Pl. 3), previously described, are composed mainly of chromophobic nerve fibres, chromophilic fibres passing only a short distance into them and then terminating. Near their points of attachment to the ganglion at least the larger of these nerves contain a few scattered chromophobic nerve cells, but no such cells were seen along further points of their course.

The hypodermis beneath the cloacal ganglion (*Hyp* Fig. 36) is of less height than elsewhere in this transverse plane of the body. Into it chromophilic nerve fibres (*Chl. F*) pass by way of the neural lamella from the ganglion. These fibres appear to end there for the most part ventrally; in one individual there were only three such fibres which bent to the right and left after entering the hypodermis.

J. The peripheral Nervous System at the posterior End of the Male.

The innervation of the vasa deferentia has been described before.

The hypodermis (*Hyp* Fig. 89, Pl. 7) just below the cloacal ganglion (*Cl. G*) is thickened in the mid line, and consists there of 1) cylindrical cuticular cells with well defined boundaries, and 2) of smaller more rounded cells between them (sensory cells?). From the neural lamella chromophilic nerve fibres pass into this hypodermis in considerable numbers (thus differing from the female) and bend there to the right and the left.

The caudal nerves. Chromophobic nerve cells in small number are found along the dorsal and lateral aspects of each nerve, for about its anterior third; they are more numerous anteriorly. About 200 μ from the posterior end of each caudal lobe each nerve bifurcates into a smaller dorsal and a larger ventral branch (*Cd. N* Fig. 46, Pl. 4); more posteriorly each of these subdivides repeatedly, until at the posterior end of the caudal lobe the nervous tissue forms a thin plate along the surface of the median hypodermis (Fig. 43). Each caudal nerve (*Cd. N* Figs. 85, 86, Pl. 7; Figs. 80, 81, Pl. 6) is composed mainly of chromophobic (*Chb. N* Fig. 43, Pl. 3; Figs. 46, 47, Pl. 4) and chromophilic nerve fibres (*Chl. F*), of chromophobic nerve cells along its anterior third, and of chromophilic cells (*Chl. C*) along its whole extent, the latter placed between the fibre mass and the hypodermis. The posterior ends of these nerves seem to be composed of chromophilic without any chromophobic nerve fibres; it is these chromophilic nerve fibres which constitute the thin plate of nervous tissue at the posterior end of the caudal lobe (close to the hypodermis, Fig. 43 *Chl. F*). The hypodermis of the median side of each tail lobe is much thickened (*Hyp* Fig. 43, Pl. 3; Figs. 46, 47, Pl. 4; Fig. 85, Pl. 7), just outside of the nerve (*Cd. N*), and there consists of two kinds of cells. 1) Cuticular hypodermal cells of long cylindrical shape with large oval nuclei (*Hyp. N*) and rather well defined cell boundaries; these are probably sensory in function, since chromophilic nerve fibres (*Chl. F*) pass into (or between) these cells from the nerve, and apparently without producing plexuses there 2) Cells (*Sen. C* Figs. 43, 47) with much smaller, rounded, pale-staining nuclei, the nucleus forming a middle dilatation in the generally spindle-shaped cell body. The proximal end of the cell (the end nearest the inner surface of the hypodermis) contains a deep-staining fibre, which in favorably situated cells may be traced into the nervous mass beneath the hypodermis; each such fibre appears usually to terminate within the cell against the proximal side of the nucleus, ending either in a loop or in a thickening. Such cells are most numerous at the posterior end of the tail lobe (Fig. 43), where the heightened hypodermis is also of the greatest extent (bounding the whole median and ventral aspect of the lobe); and over all this portion of the hypodermis the cuticula is tuberculated and lacks the areolar layer. These cells are thus very similar to the retinal cells of the eye, in containing an intra-cellular fibre which passes into the nervous system; such cells are probably sensory, and their fibres may be considered nervous in function.

Thus the chromophilic nerve fibres of the caudal nerves terminate within the hypodermis, and sensory cells of the latter send their fibres inwards into the nerves. The terminations of the chromophobic fibres could not be determined, though bundles of such fibres (*Chb. N* Fig. 43, Pl. 3) may be traced along the inner surface of the hypodermis nearly to the posterior ends of the tail lobes; probably they innervate the musculature.

The fibres of the chromophilic nerve cells could in no case be followed into the cuticula, nor to the branched roots of the cuticular tubercles.

Just anterior to the cloacal aperture the neural lamella of the cloacal ganglion divides into two, in accordance with the bifurcation of the caudal nerves in this region. In the transverse plane where the cloacal aperture is found (Fig. 86, Pl. 7) the neural lamella of each nerve (*Cd.N*) is attached to the hypodermis (*Hyp*) at the point where it passes into the cloacal epithelium (*Cl.Epi*), a few chromophilic fibres were seen to enter the cloacal wall; probably chromophobic fibres enter also, but they could not be demonstrated; thus in the male the region of the innervation of the cloaca is different from the female.

K. Function of the different Cells of the Nervous System.

We have seen that two elements occur within the central nervous system, the chromophilic and the chromophobic. The former send their fibres into the hypodermis, where they terminate generally as plexuses; such fibres penetrate for only a short distance into the cloacal nerves, and in no case could any connection of them be seen with other than hypodermal elements. The cloacal nerves of the female and the genital nerves of the male could be demonstrated to be constituted almost entirely of chromophobic nerve fibres; hence such nerve fibres probably innervate both the cloaca and the genital organs, and may be considered visceral nerve fibres in contradiction to the preceding hypodermal fibres. The innervation of the musculature could not be determined by o bservation. But it is probable that they are not innervated by chromophilic nerve fibres, since if such were the case these deep-staining fibres, which appear so sharply marked upon all suitably stained preparations, would certainly show anatomical connections with the muscle cells. Therefore, by the argument of exclusion, we might conclude that the chromophobic nerve cells innervate the musculature also, so that some of them would be motor in function. Motor nerve cells are generally larger than sensory ones, and this accords with the difference in size of the chromophilic and chromophobic nerve cell bodies. We have also seen that there are two types of the chromophilic cells, the small type and the large type (giant cells); one kind of these might innervate the musculature, the other the cloaca and genital organs.

L. The general Structure of the Nervous System.

From the preceding description it will be seen that there is no evidence of metamerism or segmentation in the nervous system. The nerve cells are evenly arranged along the whole nerve cord, and show no massing into particular ganglia; the nerve cord is not segmentally constricted; its neural lamella is a continuous, unbroken sheet; the nerve fibres which pass into this lamella and from it into the hypodermis are arranged closely one behind the other, without being arranged in particular bundles (nerves) or being regularly paired. There is no supra-oesophageal ganglion. The nerve cord is essentially an unpaired structure, and appears more distinctly tripartite than bipartite. The bifurcation of the cephalic nerves at the anterior end represents simply the here separated fibrous tracts, and the bifurcation of the caudal nerves in the male probably does not represent a primitive paired condition of the central nervous system but has been secondarily produced by the ingrowth of the cloaca. The nervous system is rather a diffuse one, nerve cells being found along the hypodermis, especially dorsally, in the whole trunk region.

Literature on the nervous system. Villot (1874) proved conclusively that the ventral cord represents the central nervous system of the Gordiacea, and described its anterior and posterior ganglion, and general anatomical structure. In 1887 he showed that nerves pass from the "ganglion céphalique" into the thickened hypodermis of the head; concluded the hypodermis to be a peripheral nervous layer; and showed that in the female of *Gordius preslii* the posterior end of the nerve cord bifurcates (this I have found to be the case also in *Chordodes morgani* Montg.). In another paper (1889a) Villot retracts his opinion of the hypodermis representing a peripheral nervous layer, and states briefly (giving no figures) that the ganglion cells have two kinds of processes, in addition to their commissures; one kind, which penetrate the "perimysium" and innervate the muscle cells; another kind, which transverse the hypodermis and terminate in the cuticular papillae, which he considers to be organs of touch.

Vejdovský strongly disputes the existence of a peripheral nervous layer, in the form described by Villot. He distinguishes two parts in the nervous system: the "Peripharyngealganglion", and the "Bauchstrang" which posteriorly forms a "Schwanzganglion". The peripharyngeal ganglion has only a single layer of ganglion cells on its upper side. The "Bauchstrang" consists of a lower ganglion-cell layer, and an upper "Nervenfaserschicht", and the radial processes from the ganglion cells divide the fibrous mass into three parts; transverse commissures occurring at intervals are also described. The peripheral nervous system, according to **Vejdovský**, is represented by nerve branches of the peripharyngeal ganglion and by the neural lamella. In a second paper (1888) he gives a fuller account of the transverse commissures of the "Bauchstrang", and finds that the neural lamella is not a continuous structure but consists of a series of "Nervenstiele", each inclosing a nerve fibre from a ganglion cell placed in the "Bauchstrang". Then he describes the "Fasersubstanz", concluding that it represents a "neurales Reticulum" or "Nervennetz" formed by the fusion of the chromatin networks of embryonic cells; in this remarkable interpretation **Vejdovský** is influenced by the results of his studies on the embryology of Oligochaeta. In his third paper (1894) **Vejdovský** shows that there is no cerebral ganglion and no ganglion cells on the dorsal side of the peripharyngeal ganglion, in correction of his earlier conclusion. He distinguishes also a "Stützgewebe" or "Glia", which is possibly comparable to my "chromophilic nerve cells", and the immediate parenchymatous envelope of the "Bauchstrang" he terms a neurilemma; there is only one true ganglion cell to be seen on a given cross section, the others cells are "Gliazellen". The "Nervenstiele" he now terms "Seitennerven", and finds them to be unpaired: "die so durch die Doppelhüllen und die Ganglienzellenfortsätze ausgezeichneten Nerven treten direct in die Hypodermis ein, um sich hier zu einem Längsstrang zu verbinden und einen mächtigen Hypodermisnerven zu bilden" (my longitudinal hypodermal nerve); he did not find lateral branches of this nerve. He concludes that "der Bauchstrang der Gordiiden nur einer Hälfte des Annulaten-Bauchstrangs entspricht. . . . Es ist aber den künftigen Untersuchungen vorbehalten, zu entscheiden, ob der ganze Bauchstrang von *Gordius* nur einem Ganglion oder der ganzen Ganglienkette der Annulaten und Arthropoden entspricht. Die derzeit festgestellten Thatsachen scheinen eher zu Gunsten der erstern Ansicht zu sprechen". **Vejdovský** has given detailed observations on the nervous system, but be has everywhere emphasized the similarities to the Annelida, and not sufficiently weighed the differences.

Camerano (1897b) states: "Il sistema nervoso consta di due masse gangliari sopraesofagee: da due cordoni nervosi che partono da esse, circondano l'esofago e si riuniscono lungo la linea ventrale mediana in un cordone unico rivestito di cellule gangliari."

Rohde (1892) finds a "fasriges Stützgewebe" between the ganglion cells and penetrating into the "Punktsubstanz", the radial fibres of which are mainly from such cells. Does not find **Vejdovský**'s segmental "Lateralnerven", nor any conjunction of nervous with muscular tissue. He also doubts the nervous nature of the neural lamella, but grants the possibility that at intervals fine nerve fibres may penetrate into this lamella.

von Linstow (1889) describes the nervous system of *G. tolosanus*, but makes no reference to the cells that compose it.

VII. The Eye.

In both sexes there is found in the anterior region of the head, above the oesophagus, a large entirely closed sack (*E. Cav* Figs. 1—4, 6, Pl. 1), the exact dimensions of which vary somewhat in different individuals. Its anterior wall is made up of much elongated hypodermal cells (*E. Hyp*), which extend backwards. Elsewhere it has a sheath or capsule (*E. Cap*) of dense and firm consistency, inserted anteriorly into the hypodermis (*Hyp*), and thickest at its most posterior part; this may be called the eye capsule. The interior of the sack is filled with a thin, pale-staining fluid (appearing as a coagulum [*Coag* Fig. 6] on preserved material), in which lie numbers of small cells, which may be termed the retinal cells (*Ret* Figs. 2, 3, 6); these are generally limited to the posterior portion of the cavity and there usually placed close to the inner surface of the capsule. Into the thickened posterior region of the capsule pass a pair of large nerve fibre bundles (*Dors. N* Figs. 2, 3, 6) coming on either side of the oesophagus (*Oes*) from the dorsal surface of the cephalic ganglion, and which may been termed above the dorsal nerves. The oesophagus below and hypodermis dorsally and laterally are separated from this organ by parenchym (*Par* Fig. 6).

The anterior hypodermal elements. These (*E. Hyp* Figs. 1, 6, 10, 11) are much elongated cylindrical cells, a modified type of the cuticular cells, and extend backwards; the inner surfaces of them are directly bathed by the fluid of the sack. Each contains one nucleus (*N* Figs. 10, 11) placed generally in the proximal third of the cell, and containing one or two true nucleoli; it is generally rounded in outline. The cytoplasm is finely alveolar and somewhat refractive next to the cuticula, elsewhere more or less coarsely vacuolar, generally so that one or two large vacuoles (*Vac*) lie near the nucleus and smaller ones in other portions of the cell body. Cross sections (Fig. 9) show very clearly that the periphery of the cell is composed of a dense layer of cytoplasm, while the axial cytoplasm is more vacuolar, and that the cells, except in the plane where they are attached to the cuticula, are separated from each other. The cuticula (*F. Cut* Fig. 10) in contact with these cells is colorless, very thin, and lacks the areolar layer; this corresponds to the white tip of the head as seen with the naked eye (Fig. 4). No nerve fibres could be found in or between these cells. Each such cell is evidently a light-guiding element, with a less refractive core and a more refractive, denser wall, each perhaps allowing the penetration of a single light ray. The thinness and clearness of the overlying cuticula would readily allow the penetration of light into these cells. In the deeper portion of this hypodermis lie much smaller, spindle-shaped cells (*E. Hyp. C. 2* Figs. 9, 11), with very small nuclei; I cannot suggest any function for these. They are more or less similar in structure to the spindle-shaped cells of the hypodermis on the latero-ventral regions of the head.

The capsule. This (*E. Cap* Figs. 2, 3, 6, 7, 13, Pl. 1; Figs. 16, 17, Pl. 2) is composed of very long and slender cells which together form a network or felting. The cytoplasm (*E. Cap* Fig. 5, Pl. 1) is dense and deeply staining, the nucleus (*N*) elongated and rich in chromatin. These are evidently modified parenchym elements, and like those which envelope the vasa deferentia of the male. The capsule constituted by them is cup-shaped with the opening in front, and thickest posteriorly. The cells of the edge of the cup are inserted into the hypodermis and reach there to the cuticula (Figs. 2, 3, 6); such endings of the capsule cells are generally branched; these branches (*E. Cap. C* Fig. 34, Pl. 3) insert themselves in the dorsal, lateral and ventral hypodermis of the anterior end of the head, and may be distinguished from the chromophilic nerve fibres occurring in the hypodermis by their deeper stain. Bundles of capsule cells also line the cephalic nerves on their dorsal and median surfaces, and form a lamella between the cephalic nerves. The chromophilic nerve fibres of the dorsal nerves (*Dors. N* Figs. 5, 6, Pl. 1; Fig. 16, Pl. 2) penetrate into the posterior wall of the capsule (*E. Cap*), there ramify and pass forwards, some to the anterior end of the capsule.

The retinal cells. In the cavity of the eye, besides the thin coagulum representing a fluid and some free spherical, non-nucleated masses, lie the retinal cells (*Ret. C* Figs. 5, 6, 13, Pl. 1). In most of the individuals examined these are placed against the posterior concavity of the capsule, but in one male they filled the greater portion of the eye cavity. These are spindle-shaped small cells (Figs. 8, 13), with a small deep-staining nucleus (*N* Fig. 8); the cytoplasm usually nearly homogeneous, sometimes alveolar, non-refractive. The two ends of the cell are attenuated and drawn out into long fibres. Those nearest the capsule wall (*E. Cap*) are generally found attached to it in pyriform clusters; the cells lying deeper in the eye cavity may in some cases be seen to be attached to the others. There is not a single epithelial layer of these cells, nor do any of them appear to be entirely disconnected from the others, but they seem to form a connected whole. By iron-haematoxylin staining (*Ret. C* Fig. 5, Pl. 1) deep-staining fibres are to be found within these cells, staining in the same way as the chromophilic nerve fibres of the central nervous system. In each cell is at least one such fibre, which generally forms a loop around the nucleus, the loop often appearing ring-shaped. Sometimes a fibre is seen to end against the nucleus (*N*), but it is probable that in such a case the loop encircles the nucleus in such a position that it cannot be seen. These intra-cellular fibres may be traced to the capsule (Fig. 5 *E. Cap*), and there seem to enter the nerve bundles (*Dors. N. B*) of the latter; the terminal ends of these fibres become much attenuated, which would speak for their being outgrowths from the retinal cells into the nerves rather than chromophilic nerve fibres which have grown into these cells from the nerve bundles. These cells have a considerable resemblance to the small sensory cells found within the thickened hypodermis of the tail lobes of the male.

There can be doubt as to the correctness of interpreting this structure as a sense organ, its rich nervous supply alone justifies this view. It might be an organ of touch, but more probably it is an organ for the perception of light, when one considers the transparent, thin cuticula on its anterior surface, the arrangement and more or less isolation of the long hypodermal elements below this (which do not appear to be sensory but simply conductive), the space with a clear fluid, and the nervous elements behind this. In an immature female from an *Acheta* in which the cuticula was still thin and white, this organ appeared much as in the adult and its cavity nearly filled with small cells; and since in this individual the organ was smaller than in the adult stage it probably reaches its maximum development and specialisation in the adult. The retinal cells are perhaps derivatives of the hypodermis, sensory elements which have separated from it. It is an eye of a unique character, and lacks pigment. However, around the posterior region of the head is found the black cervical ring (a darkening of the deeper layers of the cuticle in this region, Figs. 1, 4, Pl. 1). The functional value of this eye to the worm in its free-swimming state is obvious, in allowing it to perceive the source of light.

Literature on the eye. von Linstow (1889) is the only observer to have noticed eyes; he finds in *G. tolosanus* "Ocelli" . . . "Dicht hinter dem Scheitelpunkt, . . . liegen an der Rückenseite . . . 2 kleine, von schwarzen Pigmentkügelchen umgebene Linsen." His figure shows these only with low magnification, and from this figure it cannot be determined whether they lie in the hypodermis or the parenchym. Ward (1892) describes in detail for *Nectonema* a large closed space in the head, the "anterior chamber", which shows certain resemblances to the eye of *Paragordius.*

VIII. The Body Cavities, Mesenteries, and Parenchym.

A. In the Female.

The following is a description based completely upon the study of the adult structure. The term "body cavity" is used instead of "coelom" or "archicoel" or "schizocoel", as being less committal with regard to the origin of these spaces and their embryological values. The term "parenchym" is also employed in a very broad sense, to describe the peculiar tissue of *Paragordius* for which a large amount of a dense intercellular substance is so characteristic. It is of course not at all comparable to the loose network of mesenchym cells termed "parenchym" in the Turbellaria and other Platodes. But the term "connective tissue" is less strictly applicable, and in the adult organisation it can hardly be termed a "lymphoid tissue". Hence the word parenchym is used here simply as a designative term for convenience in description.

The body cavities. No body cavities are found in the anterior region of the body, from the anterior point of the head backwards as far as the most anterior ovaries. The head (Figs. 2, 3, 6, Pl. 1) is filled by the cephalic ganglion, the heightened sensory hypodermis, the huge eye, and a small amount of parenchym around the intestine and ganglion. There are also no body cavities in the posterior part of the trunk, from the plane where the oviducts join the atrium (Fig. 75, Pl. 5) backwards to the posterior ends of the tail lobes (Fig. 71), but the space from the body wall to the cloaca is filled with parenchym (*Par*). But in the remaining trunk region, that is for the greater part of the length of the animal, four cavities may be distinguished: the lateral body cavities, the unpaired medio-dorsal cavity, and the unpaired medio-ventral cavity.

The lateral body cavities are placed one on each side of the mid line throughout the greater region of the trunk, so that the median boundary of each is a dorso-ventral mesentery (*L. Cav* Fig. 63, Pl. 4). Laterally, dorsally and ventrally each of these cavities is bounded by the parenchymatous perienteric membrane (*Per. M*) of the corresponding side, before this membrane has become dislocated by oviposition. In the region of the most anterior ovaries (Fig. 61, Pl. 4) these cavities do not seem to be developed, since there each ovary is immediately enveloped by large-celled parenchym (*L. Par*). Each cavity is a long, unsegmented sack, semilunar on cross section, extending without interruption through the greater portion of the body though not quite as far forwards as the most anterior ovaries. These cavities are to be clearly determined in the adult stage only when the ova are being expelled from the ovaries (Fig. 63, Pl. 4). When the ovaries are filled with ova and before they have commenced to discharge them, the ovaries fill these cavities almost completely so as to practically hide them from view (Fig. 64, Pl. 4; Fig. 66, Pl. 5); but when the ovaries have emptied their contents into the uteri, the cavities are to be clearly seen with the ovaries projecting into them from their median walls (Fig. 63). The lateral body cavities are completely closed from the cavities of the ovaries and uteri. They extend posteriorly as far as do the ovaries.

The medio-dorsal cavity (*M. D. Cav* Figs. 63, 64, Pl. 4; Figs. 65, 66, 68, Pl. 5) is a smaller space and appears to be entirely closed off from the preceding cavities; it is bounded laterally and ventrally by that portion of the mesenteries (*Mes*) above the uteri (*Ut*), and dorsally from the musculature (*Musc*) of the body wall by a deflected layer of the same mesenteries, though this layer is not everywhere continuous. This cavity has on cross section generally the form of a triangle with the base directed dorsad. It does not extend forward as far as do the lateral cavities and the ventral cavity, but ends anteriorly about 4.33 mm behind the anterior end of the head. In the region of the posterior ovaries this cavity and the lateral cavities become confluent (Fig. 70, Pl. 5), and the common cavity thus formed is subdivided by bridges of large-celled parenchym.

The medio-ventral cavity (*M. V. Cav* Figs. 61, 63, 64, Pl. 4; Fig. 65, 66, 70, Pl. 5) extend further forward than the others, and backwards as far as the anterior end of the cloaca. Most anteriorly (Fig. 61, Pl. 5) it appears as a simple slit between the parenchym (*L. Par*) above and the nerve cord (*N. C*) and intestine (*Int*) below. More posteriorly its space increases in size, and throughout the greater region of the trunk it is a voluminous space in the mid-ventral line above the intestine and nerve cord, bounded dorsally and laterally by the mesenteries (*Mes*), and ventrally by the ventral deflected portion of the latter which covers the nerve cord. Posteriorly (Fig. 68) the receptaculum seminis (*Rec*) when distended nearly fills this space. The significance of this cavity will be considered again under the section "supraintestinal organ".

None of these cavities communicate with the exterior, nor with the cavities of the ovaries, uteri or intestine.

The mesenteries. There are two dorso-ventral mesenteries (*Mes* Figs. 63, 64, Pl. 4; Fig. 66, Pl. 5), which extend through the greater length of the trunk, one on each side of the median plane, and each enclosing dorsally a uterus (*Ut*). They are closely pressed against each other when the ovaries are full of eggs and the uteri empty; but when the ova have passed into the uteri they become more separated, except those portions of them which bound the median surfaces of the uteri. Dorsally they are separated by the medio-dorsal body cavity (*M. D. Cav*), ventrally by the medio-ventral cavity (*M. V. Cav*), and each is attached to the body wall dorsally and ventrally. In the anterior region of the trunk (Fig. 61, Pl. 4; Fig. 65, Pl. 5) there are no mesenteries, the large-celled parenchym taking their place; the mesenteries first become delimited with the appearance of the body cavities. Posteriorly also the mesenteries disappear with the disappearance of the body cavities (Fig. 70, Pl. 5), so that they may be said to be defined and delimited by the uteri and the body cavities. They do not envelope the intestine, in which respect they differ from the mesenteries of Annelids.

The parenchym. This peculiar tissue occurs under a number of modifications, but everywhere has the nature of connected masses of mononucleated cells, with a dense intercellular substance, the latter constituting a network of closed spaces within which the cells lie (*Par.*, *L. Par* Figs. 13, 14, Pl. 1; Figs. 15—17, Pl. 2; Figs. 61, 63, 64, Pl. 4; Figs. 65, 66, 68, 70—75, Pl. 5). The nuclei are generally large and with numerous true nucleoli, also rich in chromatin; the cytoplasm rarely appears to fill the whole cavity of the cell, on fixed material generally showing the arrangement of a coarse network of irregular strands, and is often limited (enclosing the nucleus) to one side of the cell cavity (Fig. 55, Pl. 4); probably this arrangement of the cytoplasm is an artifact due to the difficulty of the fixing reagents passing through the dense intercellular substance (which may be equally well considered fused thick cell membranes) which is firm and elastic, binding the parenchym cells into a close complex so that on hand dissections long strips of it may be pulled off intact; the cells are thus closely united together, and in the adult stage are not separate lymphoid elements lying simply in close apposition. The only region of the body where it forms a less closely connected whole is in the plane of the oviducts (Fig. 75, Pl. 5), where its cells are arranged in a loose network, but even at this region none of them appear to be free-floating. Though, morphologically considered, it cannot be ranked as a tissue of lymphocytes, since it is a firmly connected whole, yet it is even in the adult not merely a supporting tissue, for the richness of the nuclei in chromatin and true nucleoli would show it to have some important part in the metabolism of the organisation. The following three main kinds of this tissue may be distinguished, though they intergrade into each other.

1) The large-celled parenchym is especially characterized by the large size of its cellular spaces. It is found in the anterior trunk region (*L. Par* Figs. 13, 14, Pl. 1; Figs. 15—17, Pl. 2; Fig. 61, Pl. 4) where there are no body cavities, and extends backwards from that point as far posteriorly as the region of the mesenteries, from which point it is continued backwards as the perienteric membrane (to be considered in the next paragraph). In the anterior trunk region it completely envelopes the ovaries and the uteri; and anteriorly to the medio-ventral body cavity it completely invests the nerve cord also (Figs. 16, 17, Pl. 2). In the head it becomes greatly reduced in amount owing to the great development there of other organs and the heightening of the hypodermis; and at the anterior end of the head forms only a thin layer around the oesophagus. The other region of the body where this form of parenchym is well developed is in the tail lobes (Fig. 71, Pl. 5) and from there anteriorly (Figs. 72—74, Pl. 5) to the anterior region of the cloaca; here it completely fills the space between the body wall and the axial cloaca, its cells are radially grouped around the latter, and are largest next to the body wall. Anterior to this region (Fig. 75) it gradually

becomes less in amount, and from the plane of the last pair of ovaries is continued forward as the perienteric membrane (*Per. M*).

The perienteric membranes, the single representatives of the large-celled parenchym through the greater length of the trunk (*Per. M* Figs. 63, 64, Pl. 4; Figs. 65, 66, Pl. 5), are found on the sides of the lateral body cavities. They are separate from each other. Each bounds the lateral, dorsal and ventral aspects of the body cavity of its side of the trunk, but not the median surface. Throughout the greater region of the trunk this is an epithelial layer of one cell thickness (*Per. M* Fig. 37, Pl. 3); but at its anterior and posterior ends this membrane becomes thicker, passing over gradually at these points into the thickened parenchym masses of these regions, as has been described above. The perienteric membranes are not firmly attached to either the musculature externally nor to the walls of the ovaries internally, for when the ovaries are empty it is generally found disassociated from both these surfaces (Fig. 63, Pl. 4). Each membrane is deflected at its dorsal and ventral angles, and these deflected portions are apposed to the walls of the mesenteries but do not form an integral part of the latter. Each membrane appears to be a continuous sheet of tissue from before backwards, that is, is not segmented, and is composed of large parenchym cells.

2) The small-celled parenchym. In the greater region of the trunk this is represented by the tissue of the mesenteries (*Mes* Figs. 63, 64, Pl. 4; Figs. 65, 66, Pl. 5), and by the deflected portions of these which line the medio-dorsal body cavity dorsally and the medio-ventral ventrally (here forming the envelope of the nerve cord). It is generally characterized by a relatively larger amount of intercellular substance, smaller cellular cavities, and nuclei rather more rich in chromatin.

3) The fibrous parenchym is apparently a modification of the preceding, with still smaller cellular elements of elongate form, so that the tissue seems to be composed of concentrically placed spindle-shaped cells (*S. Par* Figs. 48, 49, 51, Pl. 4). This tissue starts posteriorly at the junction of the cuticular and glandular portions of the cloaca, forms a sheath next to the cloaca and further forward becomes thicker around the atrium (there also enclosing the most posterior part of the intestine, *S. Par* Fig. 74, Pl. 5), around the neck of the receptaculum seminis (*Rec. N* Fig. 70, Pl. 5) and around the descending portions of the oviducts (Fig. 75); in the latter plane a modification

of this tissue also surrounds the intestine (the medio-ventral body cavity being absent here). From the region of the oviducts forward it becomes reduced in amount, somewhat modified in structure, and is continued from there forward as the substance of the mesenteries (small-celled parenchym). Anteriorly the mesenteries pass over continuously into a large-celled parenchym, as has been shown. The intermuscular tissue may be a degenerate parenchym of this category. In the head region the sheath of the eye appears to be a fibrous parenchym, and has been described more fully under the section "Eye".

These are the only forms of connective tissue found in the body. In the female this parenchym does not seem to be degenerate in character (with the exception of the intermuscular tissue), nor yet does it seem to be proliferating since no signs of cell division were found; in fact in the adult condition it is only the ova within the uteri that show mitoses.

B. In the Male.

In individuals of this sex there are no lateral body cavities in the adult condition, but the lateral portions of the whole body are filled with the parenchym (*Par* Fig. 83, Pl. 6; Figs. 84, 87, 88, 90, Pl. 7). The medio-ventral cavity (*M. V. Cav* Figs. 83, 84, 88, 90) is well developed, has the same general relations as in the female, and extends from a short distance behind the cephalic ganglion (*M. V. Cav* Fig. 3, Pl. 1) nearly to the region of the vasa deferentia. This cavity is bounded on all sides by parenchym, and frequently, particularly in its anterior portion contains a coagulum of a staining substance (Fig. 90, Pl. 7). A medio-dorsal cavity is also present but is smaller than in the female and does not extend so far forward (*M. D. Cav* Fig. 84). The fact of there being no lateral body cavities explains why there are no dorso-ventral mesenteries in the male comparable exactly to those of the female: the median parenchymatous lining of the testes (*Tes* Figs. 83, 84, 88, 90) is comparable to that portion of the mesenteries which in the female line the median sides of the uteri; but the lateral parenchymatous lining of the testes extends to the body wall and there is no well marked perienteric membrane.

The head and the anterior trunk region as far back as the commencement of the testes is filled with a large-celled parenchym essentially similar to that of the female (Fig. 90 *Par*). In the cloacal region (Figs. 86, 87) and backwards from that to the end of the tail lobes (Fig. 85), the body is also filled with a large-celled parenchym quite similar to the relations in the female. But through the greater extent of the region where the testes are placed the parenchym has quite a different structure and arrangement from that obtaining in the female. In the anterior portion of this testicular region the parenchym elements show the following arrangement (Fig. 83): a layer of parenchym cells around each testis (*Tes*); a continuous layer of still larger cells just within the musculature (***Musc***) which is deflected upwards in the medio-ventral line by the nerve cord (*N. C*), and which corresponds in position to the perienteric membrane of the female; a layer bounding the ventro-median body cavity (*M. V. Cav*) on its dorsal aspect; and on each side of the body a layer concentric with and lying between the first two layers named, this layer disappearing in the hinder part of the testicular region of the body (Fig. 84). The cellular spaces of these parenchym elements are relatively very large, the smallest being those lining the dorsal side of the nerve cord (the latter similar to the corresponding cells in the female). The nucleus is rich in chromatin and proportionate in size to the cell cavity, the cytoplasm rather more in amount than in the female and generally close to the wall of the cellular space (this position probably an artefact due to the fixing reagents) but sometimes beautifully alveolar; in the figures such cells as show no nuclei and appear to be densely filled with the cytoplasm, are in reality of the same structure as the others but have been cut near their surfaces. But what is especially characteristic of the parenchym of the male is the comparatively large amount of the intercellular substance (compare the Figures of Pl. 7). This is dense but granular in structure and so not homogeneous as in the female; and what is not shown in the figures made from better preserved specimens, but which is to be found in more or less macerated individuals (such as those fixed in FLEMMING's fluid), bounding lines are seen to separate the concentric layers of the parenchym. The parenchym cells do not appear degenerate and filled with dark globules such as is frequently the case in *Gordius* and *Chordodes*.

The male in regard to its body cavities and parenchym layers is thus quite different in appearance from the female, and this difference seems to be mainly due to the absence in the adult male of the lateral body cavities, which in its turn may be induced by the different structure of the genital organs.

Enveloping the vasa deferentia (*Vas* Fig. 89, Pl. 7) are sheaths of parenchym (*Vas. S*) of a fibrous nature (the parenchym in the form of long spindle-shaped cells), quite similar to those which form the sheath of the eye.!

Literature on the body cavities, mesenteries, and parenchym. Villot (1874, 1887, and other papers) considers the "parenchyme" to be an embryonic mesodermal tissue filling the whole "blastocoele"; that it becomes absorbed in the development of the ovaries and testes and so decreases in amount during the development. In another paper (1891) he considers the parenchym to constitute an alimentary reserve; that all the adult body cavities are formed by "régression" of the parenchym; and that "Il n'existe chez les *Gordius* adultes ni coelome, ni rien que l'on puisse assimiler aux mésentères des vers coelomates". Vejdovský (1886, 1888, 1894), on the contrary, holds that the parenchym, "Zellkörper", is not an embryonic reserve tissue but reaches its greatest development in the adult; that in the immature condition the body cavity ("Cölom") is large, and lined by a "splanchnisches" and "somatisches" epithelium, as in Annelida. He is the discoverer of the "Rückencanal", and describes and compares the mesenteries with those of Annelida. Under the name "Cölom" he understands what I have called the "lateral body cavities". All the facts he reviews as a basis for these comparisons I need not mention here, since they are based mainly upon the embryonic changes, and my paper deals essentially with the adult anatomy. Vejdovský regards the "Zellgewebe" not as a connected whole, but as consisting of densely crowded "Lymphoidzellen", on the basis of an experiment, where on isolation of these cells they appeared amoeboid; in other words, he did not find any dense intercellular substance, but regards them as free cells, and hence opposes the usage of the term "parenchym". According to him, the "Ovarien" in this growth push the splanchnic against the somatic peritoneum, so that at first they do not lie within the "Cölom"; but that the ova later come to occupy a virtually intracoelomic position, by reason of the disappearance of the splanchnic layer.

von Linstow (1889) also uses the term "Zellkörper" for the parenchym and finds the cells to be arranged in "segmented" transverse rows; this segmentation he regards as a point of similarity with the Annelida, disregarding the fact that these animals have no such tissue in their organisation. The "Leibeshöhle" he limits to the periintestinal cavity, considering all the other cavities as part of the reproductive systems.

Camerano states (1888a, 1897b): "Non è dimostrata l'esistenza di una vera cavità del corpo; gli interstizii fra i vari organi sono occupati da un tessuto connettivo con grosse maglie e da connettivo fibroso."

IX. The Supra-intestinal Organ.

In one adult female there was found a remarkable organ lying on the dorsal side of the intestine, its whole length being 6.4 mm, and its most anterior end placed 2.56 mm behind the anterior end of the head (these measurements being determined on a series of sections through the whole organ). This structure consists of a longitudinal tube closely applied to the dorsal side of the intestine, and of lateral branches which embrace the sides of the latter (*S.I.O* Figs. 18—21, Pl. 2).

The dorsal tube is attenuated anteriorly and without a lumen (Fig. 21); 73 μ behind this a closed lumen begins and continues closed for a distance backwards of 1.18 mm; in all this region the tube is dorso-ventrally flattened. Behind this portion the tube shows a more or less circular lumen (Figs. 18, 19) which extends nearly to its posterior end; the posterior end is attenuated as is the anterior. Both ends of the longitudinal duct are thus closed, and the duct does not stand in open communication with the intestine, nor yet with the body cavity (except though the mediation of the lateral branches of the organ). This dorsal tube varies greatly in its diameter at different portions of its course, and a large swelling may be immediately followed by a constriction, and its lumen likewise varies in diameter and at some points is broken up into a number of separate lumina. The substance composing the wall of this dorsal duct is almost homogeneous in character, and stains faintly with eosin; it shows no bounding outer layer. The substance is compact except that at some points clear vacuoles of varying size occur in it. The lumen of the duct is for the greater part of its extent bounded by a line that stains deeply with haematoxylin; and it is the presence of this deep line at the anterior end of the tube which permits us to say that a lumen is there but a closed one (Figs. 20, 21).

From the dorsal duct are given off 26 branches on one side and 22 on the other; Fig. 12, Pl. 1, is a reconstruction showing the relative positions of these branches, though in this reconstruction the differences in the diameter of the lateral branches and the presence of contractions and dilatations of the dorsal duct are not shown. These branches are given off latero-ventrally from the dorsal duct, and embrace the sides of the intestine (Figs. 18—20, Pl. 2); some extend ventrally as far as the lining of parenchym beneath the intestine (*Int*), others reach only half so far. The diameter of these branches varies considerably, some being of great thickness and extending over a number of sections (sections $6^2/_8\ \mu$ thick), others being smaller. Most of the branches either fork at their free ends, one portion passing a short distance forward and the other backward, or else the free end without branching bends either forward or backward. The free ends of these branches, at least of those which extend down the whole side of the intestine, generally diverge away from the intestine. The substance of these branches is like that of the dorsal duct. But in general they contain many more vacuoles, and in some cases it can be positively determined that the most ventral of these vacuoles open into the body cavity (here the medio-ventral cavity (Fig. 18, left side). The vacuoles and irregular spaces within some of the branches appear to form a ramifying canal system, which opens at the one end into the body cavity and at the other into the lumen of the dorsal duct. None of these parts showed any indications of openings into the intestinal lumen. Some of the lacunae, especially those which stand in open communication with the body cavity, are bounded by a line staining deeply with haematoxylin, as in the case with the lumen of the dorsal duct. In the anterior region where the lumen of the main duct is closed, the lumina of the branches are likewise closed (Fig. 20).

As the reconstruction shows (Fig. 12), the branches of the one side alternate for the main part with those of the other, and it is unusual to find the branches paired.

It is most remarkable that this organ appears to possess no nuclei of its own. Small deep-staining nuclei are found in it (about 29 in number), but from the close resemblance of these (*Par. N* Fig. 21) to the nuclei of the parasitic organisms found in the lumen of the medio-ventral canal, they certainly belong to such parasites which have penetrated the wall of the organ. Sometimes such parasitic cells are merely apposed to this organ, sometimes only partially imbedded in its branches, sometimes wholly imbedded and in the latter case the boundary of the imbedded cell cannot be distinguished from the substance of the surrounding organ, though the imbedded cell may be recognized as belonging to one of these parasites by the peculiarities of its nucleus.

This remarkable organ, without nuclei and without cell boundaries in its organisation, is difficult to interpret except as an organ abnormally retained in the adult condition but proper to an earlier stage. In no other adult, male or female, was any trace of it to be found; and in several individuals of this species, as well as of *Chordodes morgani* and *Gordius aquaticus robustus*, the whole intestine was dissected out and then stained and mounted, but none of these dissections showed such an organ attached to the intestine in any portion of its course. This organ is essentially a longitudinal canal with lateral branches that open into the body cavity, but with no open communication into the intestine to which it is so closely attached. From these characteristics it might be considered an excretory organ, perhaps taking up fluids from the body cavity and by osmosis passing them over into the intestine. In any case we may conclude that this organ is seldom retained into the adult stage, that it properly belongs to an earlier period of the ontogeny, and that from its unpaired nature and other structural connections it represents a new type of excretory organ.

This organ as we have seen lies in the medio-ventral body cavity. In some adult males, more rarely in females, a staining coagulum is found in this cavity, particularly in the anterior portion of its extent (*M. V. Cav* Fig. 90, Pl. 7). This may well represent an excretory fluid, and perhaps in the adult condition the medio-ventral cavity represents an excretory space. In one male was found, however, besides this faintly-staining coagulum, a denser staining substance in this portion of the body cavity (Fig. 90); and this latter may well represent degenerated substance portions of an excretory organ such as that found in the female described. In any case, in the adult organisation the only structure that normally represents an excretory organ is the medio-ventral body cavity, and since this is not connected with any openings in the body wall, the excretory fluids which it contains must pass by osmosis into the cavity of the intestine. Yet at an earlier stage there is within this cavity, in close contact with the dorsal surface of the intestine, an unpaired excretory organ with lateral branches; and this organ only rarely persists into the adult stage. In an immature female with white cuticula and with the muscular epithelium still in process of differentiation, taken from the body cavity of an *Acheta*, no trace of such an organ was found; accordingly it must normally be functional at a still earlier stage, perhaps in individuals of only a few centimetres in length.

Literature on excretory organs. **Vejdovský** (1886) describes the medio-ventral body cavity, which he was the first to discover, as an "Excretionsröhre", on the basis of finding a fluid coagulum within it; but he regards it as without a morphological equivalent in other groups. Later (1894) he considers it to represent the "primäre Leibeshöhle". He also describes under the name "braune Drüse" a rudimentary tubular structure composed of large cells, the "Drüsenkörper", and an "Ausführungsgang" which opens into the oesophagus; this organ, not found in the adult, may possibly correspond to what I have termed the "supra-intestinal organ".

Villot (1887, 1889b, 1891) considers the "cavité péri-intestinale" to be a space formed by the "regression" (shrinkage) of the intestine in the adult stage, and by the fatty degeneration of the parenchym. He regards (1889a) the hypodermis "bien un appareil aquifère, qui communique avec l'extérieur par les canalicules et les pores de la cuticule".

von Linstow (1889) regards the periintestinal space as the only body cavity in the adult, but opposes **Vejdovský**'s view that it is an excretory organ.

Camerano (1897b) states: "Non vi è traccia sicura di apparato circolatorio e di apparato escretore, almeno nello stato adulto."

X. The Female Genital Organs.

These consist of the ovaries (*Ov* Fig. 78, Pl. 6), segmentally arranged sacks placed on the right and left sides of the body, and extending from the anterior region of the trunk in front nearly to the anterior end of the atrium (*Atr*) behind; the uteri (*Ut*), a pair of tubes suspended in the dorso-ventral mesenteries, and having the same extent as the ovaries; the oviducts (*Ovi*), the posterior narrowed continuations of the latter, and which connect with the dorso-lateral angles of the atrium (*Atr*), a glandular sack; the receptaculum seminis (*Rec*), a long sack extending forwards above the nerve cord and opening posteriorly into the anterior end of the atrium; and the cloaca (*P. Cl*, *Cu. Cl*), a long tube starting at the point where the intestine (*P. Int*) connects with the posterior end of the atrium, and passing backwards to the cloacal aperture situated between the tail lobes (*D. T. L*, *L. T. L*).

The appearance of the genitalia varies in different individuals, according to the stage of the reproductive activity. In individuals which have just left the body of their last hosts, and which have not been fertilized, as well as those in the terminal host but of mature structure, the ovaries (*Ov* Fig. 66, Pl. 5) are so densely distended with ova that the lateral body cavities are obliterated, the uteri (*Ut*) are empty and appear as narrow slits, and the receptaculum (*Rec*) is folded. In individuals which have been fertilized and which are in process of discharging their eggs, the uteri (*Ut* Fig. 64, Pl. 4) are distended with ova which have passed into them from the now smaller ovaries (*Ov*), ova are found in the oviducts (*Ovi* Fig. 68, Pl. 5) and the atrium (*Atr* Fig. 75, Pl. 5) and cloaca (in the latter, *O* Fig. 72, agglutinated into a long string), and the receptaculum (*Rec* Fig. 68, Pl. 5) is filled with spermatozoa (*Sp*), spermatozoa being also found in the atrium and the cloaca. Finally when the egg string has been nearly wholly deposited outside of the body, the ovaries are collapsed sacks (*Ov* Fig. 63, Pl. 4) so that the lateral body cavities (*L. Cav*) appear very clearly, a few ova (*O*) remain in the uteri (*Ut*) and oviducts, and the atrium and cloaca are filled with that portion of the egg string which has not yet been deposited. When all the eggs have been deposited, the whole body is more or less collapsed, ribbon-shaped instead of cylindrical, being greatly flattened dorso-ventrally. One individual kept in an aquarium until all the eggs had been discharged, died at the end of this process. And in view of the facts that the oviposition induces very considerable rending and tearing of the internal organs, especially the perienteric membranes and the mesenteries, and that at no points upon the germinal epithelium are to be found any growth centres of a new generation of ova, it is probable that completed oviposition means death for the individual. These worms lay their eggs even when not fertilized, as I conclude from an individual kept in an aquarium, the deposited ova of which underwent no cleavage (and in this case they were not laid in connected string, the usual manner, but in disconnected masses).

The ovaries. These are epithelial sacks closed at all points except medially where they open into the uteri. When filled with ova and before the commencement of oviposition, each may be likened in form to a half disc (*Ov* Fig. 66, Pl. 5), flattened before and behind by the pressure of others in front and behind, curved on that surface next the concavity of the hypodermis, straight on the median surface next the mesentery (*Mes*). At this stage the ovary is distended with ova, and completely fills the lateral body cavity. The epithelial lining is often very difficult to see clearly at this stage, since by the distension of the ova upon it it is stretched out to form a very thin membrane. This is a direct continuation of the lining of the uteri (*Ut* Fig. 64, Pl. 4), and may be termed the germinal epithelium. When fully stretched out before the time of oviposition it appears on cross section as an exceedingly thin line, and where it is closely apposed to an ovum is indistinguishable from the membrane of the latter. But during or after the discharge of the ova the wall of the ovary contracts, the tension upon it being removed, and the whole organ then represents a collapsed and folded sack (*Ov* Fig. 63, Pl. 4; Fig. 77, Pl. 6) attached to the wall of the uterus (*Ut*). At this stage it can be readily determined that it is completely closed against the lateral body cavity, all of its ova passing into the uterus and none of them into that body cavity. Then its lining, the germinal epithelium (*G.Epi* Fig. 77, Pl. 6), does not appear even but is much folded, and these folds have in general the form of rays diverging outwards from the point of their attachment to the uterus. And even before the discharge of the ova the latter can be seen to have a corresponding radiating arrangement within the ovary (Fig. 66, Pl. 5). These rays or lobules of the ovary are further subdivided or branched at their ends, so that the whole organ presents a racemose arrangement when it is empty; the same arrangement of course holds also during its distended condition, but then the continuity of the epithelium cannot be so well determined. When empty the germinal epithelium of each ovary is much thicker (Fig. 77, Pl. 6), and is then found to consist of an epithelium with disc-shaped nuclei, none of them in stages of mitosis; the epithelium then arranged more or less in the form of a loose and irregular network, the meshes of which correspond to the spaces previously occupied by the ova; the finer cytoplasmic strands of this network evidently correspond to earlier individual compartments for the ova.

The lobular subdivisions of the each ovary probably represent divergent terminal branches which have grown out from a single one arising from the lateral wall of the uterus; this would explain the convergence of all the lobes to one point, and is in accord with the observations of Vejdovský on the development of *Gordius*.

The ovaries are arranged close behind each other in each lateral body cavity (*Ov* Fig. 62, Pl. 4; Fig. 67, Pl. 5; Figs. 78, 79, Pl. 6); they touch each other when distended with ova, otherwise small spaces separate them, these spaces being largest between the most anterior ovaries; these most anterior ovaries are also the smallest, and are immediately invested by large-celled parenchym (*L. Par* Fig. 61, Pl. 4), i. e. do not lie within a lateral body cavity. They are apparently strictly bilaterally arranged and paired, as may be determined by cleared specimens in oil (Fig. 62), and by counting their openings into the uteri, though such openings are not always strictly symmetrical. In the region of their most posterior occurrence in an ovipositing female, in an extent of the trunk of 5.4 mm, 101 were found on the right, and 100—101 on the left. In the most anterior trunk region they are somewhat less numerous, here along an extent of 6 mm only about 90—100 pairs being found. From these counts made upon a female of 250 mm total length, the total number of pairs of ovaries would be between 3000 and 4000, probably nearer the latter number.

Though thus segmentally arranged, and regularly paired, their arrangement cannot be regarded as indicating a metamerism of the body, since it is highly improbable that any animal consists of nearly 4000 metameres.

The uteri. These are a pair of long tubes (*Ut* Figs. 61, 63, 64, Pl. 4; Figs. 65—68, Pl. 5) lying in the dorsal portions of the mesenteries (*Mes*); they are not segmented. Before the ova have entered them from the ovaries, the lumen in each is simply a nearly obliterated vertical split (*Ut* Fig. 66); and their anterior ends (Fig. 61) being imbedded on all sides by large-celled parenchym (*L. Par*) are at all times very narrow, so that the ova in transversing these portions become greatly flattened. Each has a lining continuous along its whole extent in the form of a flattened epithelium, exactly similar to that which lines the ovaries, and which may be called the germinal epithelium; it is thinnest most anteriorly (Fig. 61), more posteriorly becoming gradually thicker. Its finer structure is shown at *G. Epi* Figs. 42, 45, Pl. 3. At regular intervals openings in the lateral wall of each uterus (*Ut* Fig. 64, Pl. 4; Figs. 65, 66, Pl. 5) connect with the cavities of the contiguous ovaries (*Ov*); or in other words, each uterus wall shows segmentally arranged diverticula which are the ovaries. The lumen of each uterus is largest when it is filled with ova, and the ova in it are much more closely pressed together than when they were in the ovaries (Fig. 64). The mechanism of the discharge of the ova into the uteri, is probably the direct contraction of the walls of the ovaries.

Distinction of ovaries and uteri. In the preceding description I have used "ovary" in the place of Vejdovský's term

"Eiersack", and the term "uterus" as he has used it. The term "ovary" as used by Vejdovský would apply to only the earliest single-lobed stage of the germinal epithelium; but since this epithelium always forms a continuous sack around the ova, so that the latter do not escape from it into the body cavity, its cavity must be interpreted as the ovarian cavity, and hence the whole organ as an ovary, even though the earliest proliferation of the ova may proceed from its medial side alone. This can be deduced even from the mature stage, when one considers the appearance of the ovaries when they are empty. Hence in *Paragordius* the term "Eiersack" is fully equivalent to ovary. As for the name "uterus", I have used Vejdovsky's term simply in order not to introduce a new one; but it is not strictly an uterus, since the ova are not fertilized within it nor do they undergo their development there (except the first maturation division). Its function is simply to conduct the ova to the cloaca and so to the exterior. A very different morphological interpretation of the ovaries and the uteri seems to me to be demanded, in view of the fact that both are lined by the same germinal epithelium. This is, that in *Paragordius* the whole uterus of one side of the body together with the ovaries attached to it may be considered one ovary, so that there would be present a single pair of very long ovaries, each with lateral segmental diverticula. The whole relations of these parts in the adult condition bear out the correctness of Vejdovský's observations on the development, for he found that the germinal epithelium first proliferates ova within the uterus, at the points where the latter becomes laterally bulged out. Hence I would interpret the ovaries of *Paragordius* as a single pair of very long tubes lined throughout by the germinal epithelium, with segmental lateral points of proliferation for ova on each, these growth zones becoming finally bulged outwards into the lateral body cavity in the form of the ovaries or Eiersäcke as these terms are used by Vejdovský. This interpretation brings the female egg-producing organs under the same aspect as the male sperm-producing, the main difference in the male being that the testes do not have lateral diverticula.

Accordingly it is only for convenience in description that I have distinguished the main tube and the lateral diverticula of the true ovary, as uterus and ovaries respectively.

The oviducts. These (*Ovi* Figs. 68, 70, 75, Pl. 5; Figs. 78, 79, Pl. 6) are the narrowed posterior ends of the uteri. They extend straight backward to the plane of the anterior end of the atrium

(*Atr* Figs. 75, 79), where both bend and pass ventrad to open into the atrium at its dorsal antero-lateral angles, these descending portions of the tubes being the narrowest. Each oviduct has thus a horizontal and a vertical arm. The former portion consists of an epithelium (*Ovi* Fig. 49, Pl. 4) which is ciliated, this being the only ciliated epithelium in the whole body (in the male there is no ciliation at all); this epithelium has a lining of cubical cells of exactly the same character as the germinal epithelium which lines the uterus, but is thicker; the cilia (*Cil*) are arranged in tufts, not evenly scattered over the surface of each cell, and are simple cilia. The oviduct may be said to continue as far forward as the ciliated epithelium extends (Fig. 79, Pl. 6), namely to the plane of the penultimate pair of ovaries (*Ov*), the ciliation not extending into the ovaries. The vertical arm (Fig. 75, Pl. 5; Fig. 79, Pl. 6) of each oviduct is not ciliated, of a narrower calibre than the preceding portion, so that the ova must pass through it in single file. Very few spermatozoa are to be found in fertilized females in the posterior part of the oviducts; and it is probable that the ciliation acts to keep spermatozoa from penetrating into the uteri rather that to drive the ova backwards. The oviducts are imbedded in a small-celled parenchym (*S. Par* Fig. 49, Pl. 4; Fig. 75, Pl. 5).

The atrium. The posterior end of this organ (*Atr* Figs. 78, 79, Pl. 6) is coincident with the place of junction of the posterior intestine (*P. Int*) with the cloaca (*Gl. Cl*); its anterior end is produced in the form of two lateral horns which connect with the oviducts (*Ovi*), and into a medio-ventral continuation which connects with the neck (*Rec. N*) of the receptaculum seminis. The atrium is cylindrical and narrow posteriorly (*Atr* Fig. 74, Pl. 5), anteriorly it becomes enlarged laterally and by median indentations from above and below shows an incomplete division into a right and a left half. It is lined internally by glandular epithelium (*Atr* Figs. 74, 75) and externally by a sheath of small-celled parenchym (*S. Par*). The epithelium is produced into finger-shaped folds (*Gl. C* Fig. 51, Pl. 4) which project radially into its lumen, each fold representing a radial distribution of gland cells around an axial rhachis formed of the fused stalks of the cells. The gland cells are more or less coarsely vacuolar according to the stage of formation of the secretion, which is a thin, colorless fluid that does not imbibe any of the stains employed. It is probably this secretion, together with that of the glandular portion of the cloaca, which forms the hard, transparent egg membranes.

The receptaculum seminis. This long sack (*Rec* Figs. 78, 79, Pl. 6) connects by its constricted posterior end (neck, *Rec. N*) with the atrium (*Atr*), and extends forward in the medio-ventral line above the nerve cord, displacing the intestine (*Int*) from its usual position, so that the latter is either forced to one side of or above the receptaculum. It is much folded (*Rec* Fig. 66, Pl. 5) when not filled with spermatozoa, but when so filled (*Rec* Fig. 68) rounded and of much greater diameter. Its wall (Fig. 53, Pl. 4) consists of a flattened epithelium with disc-shaped nuclei (*N*) and vacuolar cytoplasm; in the constricted neck region the epithelium is much folded and the lumen almost obliterated (*Rec. N* Fig. 70, Pl. 5). Encircling the neck is a sheath of small-celled parenchym (*S. Par*) which diminishes in thickness anteriorly so that the larger portion of the receptaculum is bounded laterally only by the thin dorso-ventral mesenteries, which are modified anterior continuations of the small-celled parenchym.

Structure of doubtful importance. In two individuals only there was found in the mid line, imbedded in the parenchym between the intestine and the neck of the receptaculum seminis, a saccular structure (*X* Fig. 70, Pl. 5; Fig. 79, Pl. 6) with a flattened cellular wall and vacuolar fluid contents, but with no opening into either the intestine (*Int*) or the receptaculum seminis (*Rec*), though it comes into contact with both these organs. The lining epithelium of this organ has somewhat the same character as the wall of the intestine in this region of the body. This probably represents some organ, or part of an organ, which is functional at an earlier stage only, and may be a diverticulum of the intestine.

The cloaca. This (*Gl. Cl*, *Cu. Cl* Figs. 78, 79, Pl. 6) is an axial cylindrical tube, narrowest anteriorly and gradually enlarging posteriorly, which extends from the posterior end of the atrium to the posterior end of the body. The cloacal aperture is the space embraced by the three divergent tail lobes, and at their ends the epithelium of the cloaca passes continuously over into the hypodermis of the external surface of the body. *Paragordius* differs most markedly from *Gordius* and *Chordodes* in respect to this organ, for while in the latter genera the cloaca is exceedingly short, in *Paragordius* it reaches a length of than 6 mm. The length of the cloaca in its relation to the neighboring parts of the genital apparatus is shown in Fig. 78. It not only serves as the canal for the entrance of the spermatozoa to the receptaculum and for the passage of the ova to the outside of the body, but also for the discharge of the contents of the intestine (the intestine connecting with its dorsal side at its most anterior end). There are two sharply distinguishable portion of the cloaca: 1) a much shorter anterior glandular portion (*Gl. Cl* Figs. 78, 79), and 2) a much longer posterior cuticular portion (*Cu. Cl*). It is the latter portion that from its structure appears to be invaginated hypodermis, i. e. a proctodaeum; while the glandular is so different histologically that it has probably a different embryonic origin.

The anterior glandular portion (*Gl. Cl* Figs. 78, 79) has a length in an individual of 248 mm, of only 253 μ, and is lined exteriorly by a sheath of small-celled parenchym. Its wall consists of a high, glandular epithelium (*Gl. Cl* Fig. 48, Pl. 4), which secretes a thin fluid (*Gl. Secr*) that stains red with eosin and generally appears coagulated. Before oviposition these cells are slender, but during oviposition they are more rounded, often nearly spherical, owing to the accumulation of secretion within them. Posteriorly, where this glandular region joins with the cuticular region of the cloaca, is found the narrowest portion of the cloacal lumen (Fig. 79, Pl. 6), and there the glandular epithelium is deflected to form a ring; this constriction would probably act as a valve.

The posterior cuticular cloaca (*Cu. Cl* Figs. 78, 79) is sharply demarcated from the anterior. Most posteriorly, on the inner surface of the tail lobes, the cloacal epithelium (*Cl. Epi* Fig. 71, Pl. 5) is exactly similar to the hypodermis (*Hyp*) that lines the outer surface of the tail lobes, except that the cuticula (*Cl. Cut*) on their inner surfaces lacks the areolar layer. By a perfectly gradual change in structure the cloacal epithelium becomes different more anteriorly (*Cl. Epi* Figs. 50, 54, Pl. 4; Figs. 71—73, Pl. 5); and from behind forwards not only does the lumen of the cloaca decrease in diameter, but the epithelium becomes gradually thicker. At the anterior end of the cuticular cloaca, where the cuticula is naturally of a black color (*P. Cl* Fig. 78, Pl. 6), the epithelium is very high and composed of cylindrical cells (*Cl. Epi* Fig. 50, Pl. 4) with larger nuclei (*N*), between which are smaller, clearer cells with much smaller nuclei, probably gland cells. The cuticula (*Cl. Cut*) in this region is not clearly demarcated from the substance of the cell bodies, but beneath the very thin homogeneous layer (*H. Cut*) of the outer cuticula is a non-lamellated cuticula which covers the ends and sides of the large epithelial cells, as shown in Fig. 50. This portion of the cuticula, which corresponds in position to the fibrous cuticula of other regions is seen to be very thick, and composed of radiating fibres (fibres parallel to the long axis of the cell); thus each large epithelial cell shows a basal, coarsely vacuolar cytoplasm around the nucleus, on this follows a very finely-alveolar cytoplasmic portion, and upon the latter a cuticulated cytoplasm, which increases in density terminally on account of the convergence of its fibres. Such a structure of the cloacal epithelium, which is found only at the most anterior end of the cuticular cloaca, passes posteriorly by gradual stages (Fig. 54, Pl. 4) into the hypodermal-like epithelium which lines the inner surfaces of the tail lobes (*Cl. Epi* Fig. 36, Pl. 3; Figs. 71—73, Pl. 5). In other words, the further removed from the cloacal aperture, the greater is the difference from the external hypodermis, throughout this extent only the outer homogeneous cuticula remaining uniform. It is very probable that this gradation of cuticular structure corresponds to a gradation in final perfection of the cuticula: that most posteriorly is found a completed cuticula sharply demarcated from the cytoplasm beneath, more anteriorly a cuticula still in process of formation and hence not sharply delimited from the underlying cytoplasm. And if this be true, the process of cuticularisation would be as follows: the cuticular substance is first deposited in the greater portion of the cell body distal to the nucleus; its further development consists in its gradually becoming condensed near the surface of the cell, and becoming sharply delimited from the cytoplasm. Here is then one region in which the process of cuticularisation may be followed in the adult organisation.

The cuticular region of the cloaca is enveloped upon all sides by large-celled parenchym (*L. Par* Figs. 71—73, Pl. 5), the small-celled parenchym not extending posterior to the glandular cloaca. The parenchym is so closely united with the wall of the cloaca that it cannot be dissected off of the latter.

The ova. In the ovaries of the individuals examined all the ova are ovocytes of the first order, and have attained their full size. The nucleus (*N* Fig. 69, Pl. 5) is spherical, with a faintly-staining nuclear sap which in the resting stage shows no trace of a chromatin reticulum, and one large "nucleolus", which stains with both cytoplasmic and chromatin stains. Immediately around the nucleus is a zone of rather coarsely vacuolar cytoplasm, the alveoles arranged in concentric lamellae; then a zone of yolk substance (*Yk*), in the form of irregular spherules of various dimensions; and most externally a zone almost free of yolk and of a finely-alveolar structure. No sign of a centrosome or attraction sphere was to be seen. Just as the ova enter the uteri they are all in the prophase of the first maturation division, and in the uteri the small spindle is found near the centre of the egg; apparently the first pole body is not cut off until the ova have passed out of the body. The details of the maturation are reserved for a separate paper; here it may simply be noted that during the first maturation mitosis the achromatic spindle is very small, much as in *Ascaris megalocephala*, and the number of the minute chromosomes apparently seven; and during this maturation the yolk becomes much more finely subdivided and regularly distributed throughout the cell. In the adult condition all the ovarian ova are of the same definitive size..

Literature on the female genital organs. Here it is not necessary to consider all the anatomical differences of detail described by the different authors, for considerable differences, particularly in the cloacal region, are found in the different genera. Hence we may consider mainly that literature describing the ovaries, and the different terminologies; here it may simply be mentioned that no writer has noticed the ciliation of the oviducts.

VEJDOVSKÝ (1886) distinguishes as "Eierstöcke" the segmentally arranged proliferating points of the ova, and he is the first to call attention to this segmentation; these he observed on females at the end of oviposition. From these "Eierstöcke" the ova detach themselves and fall into the spaces, "Eiersäcke", which he regards as coelomic cavities; these, when filled with ova, are what the preceding authors had described as "Eierstöcke" or "Ovaries", and the ova in them are represented as not surrounded by the germinal epithelium. "Es existirt später keine Leibeshöhle mehr, indem sie eigentlich von den Eiersäcken eingenommen wird." He describes then the "Eibehälter", regards then as produced by splitting of the mesenteries, and as lined simply by parenchym. The posterior ends of the "Eibehälter" are called "Eileiter". In his next paper (1888) VEJDOVSKÝ described the young "Eierstöcke", first finger-shaped, later lobular cell outgrowths from the wall of the mesentery, each "Eierstock" lined by the germinal epithelium; "nach den gegenwärtigen Beobachtungen gelangen die Eier aus den Ovarien direct in die Eibehälter, und erst die später sich entwickelnden Elemente fallen, aus Mangel an genügendem Raum in den Eierstockslappen, in die Leibeshöhle". He notes that the ova in the body cavity show nuclei, those in the "Eibehälter" do not; evidently the latter are then in the maturation process. In this paper he describes the epithelial lining of the "Eibehälter", considers that the latter are formed before the mesenteries, are "vielleicht modificirte Excretionsorgane". In his third paper (1894) Vejdovský describes the development of all these organs: the "Ovarien" arise as segmental outgrowths of the paired "Gonaden"; the growth of the "Ovarien" forces the "splanchnic" against the "somatic" layer of the peritoneum, so that the "Ovarien" do not lie in the "Cölom". Though Vejdovský noted the radial arrangement of the ova in the ovaries, he failed to note that this is due to the persistence of the lobular walls of the germinal epithelium.

Villot (1887) describes a single tubular pair of ovaries, each with two tubular, parallel branches; one lateral (equivalent to Vejdovský's "Eiersack"), the other dorsal (equivalent to Vejdovský's "Eibehälter"); the medio-dorsal body cavity he considers an unpaired tubular branch, a part of the reproductive system. All of these he finds to be lined by the same kind of epithelium. In another paper (1889c) he describes two "tubes ovariens" in the dorsal region, comparable to the "tubes testiculaires", each with an external "conjunctive" and an inner epithelial layer; the ova develope in lateral diverticula ("graffes ovigères") of the "tubes ovariens", and are formed by lateral evagination of the latter, but this is a continuous and not a segmental evagination. "L'ovaire des Gordiens comprend à la fois ce que Vejdovský désigne sous le nom d'ovaires et du réceptacle des œufs (Eibehälter)." The ova pass first into the ovarian tubes when mature, in consequence of this increase in volume in conjunction with the pressure of the lining epithelium. The Gordii reproduce only once in a life time.

von Linstow (1889) describes the genital organs as consisting of: two "Ovarien", each a long tube with an epithelial lining (= Vejdovský's "Eiersack"); two "Eiersäcke" (= Vejdovský's "Eibehälter"); and the "Rückencanal", which also contains ova after oviposition. The "Ovarien" after oviposition show only "eibildende Drüsen" on their inner walls (these equivalent to the "Eierstöcke" of Vejdovský, 1886). In another paper (1891) von Linstow describes more fully the "Rückencanal" (my medio-dorsal body cavity); he finds that at its anterior end it communicates by two branches with the "Eiersäcke", and at its posterior end with the "Ovarien"; he concludes that the last ova to be discharged pass into this canal at its posterior end, along it anteriorly and so into the "Eiersäcke", then posteriorly in the latter to the cloaca. (The mechanics of such a process are practically impossible of explanation; I think it probable that the openings of this canal into the genital ducts are either artefacts, or produced by hernia during oviposition.)

CAMERANO (1897b) has very poorly understood the structure of the genital organs, he states: "L'apparato riproduttore femminile consta di due lunghi ovarii con due lunghi ed ampi ovidotti."

Thus the literature shows great divergence of opinion in the interpretation of these organs. VEJDOVSKÝ has given the most detailed descriptions, and laid the greatest stress upon the fact that the growth zones of the ova are segmental. He did not see that the germinal membrane is continuous around the ova when in the "Eiersäcke", and did not recognize the great difference from the Annelida in the ova developing outside of the body cavity. VILLOT's descriptions are similar in the main to those of VON LINSTOW, but neither recognized that the "graffes ovigères" or "eibildende Drüsen" are segmentally arranged. My term "uterus" corresponds to VEJDOVSKÝ's "Eibehälter", to VILLOT's "dorsal paired branch of the ovary", and to VON LINSTOW's "Eiersack". My term ovary, as used in the restricted sense, is equivalent to VEJDOVSKÝ's "Ovarien" together with the "Eiersäcke" (assuming the latter to be composed of a series of closed sacks), and to VILLOT's "graffes ovigères" together with his "lateral paired branches". As the idea "ovary" should be employed in the broad sense, I agree with VILLOT: "L'ovaire des Gordiens comprend à la fois ce que VEJDOVSKÝ désigne, sous le nom d'ovaires et du réceptacle des œufs (Eibehälter)."

XI. The Male Genital Organs.

These consist of the paired testes, the paired vasa deferentia, and the unpaired cloaca.

The testes. These (*Tes* Figs. 80, 81, 83, Pl. 6; Figs. 84, 88, 90, Pl. 7) extend continuously through the greater part of the trunk, beginning anteriorly a short distance behind the cephalic ganglion, where they are narrowest (Fig. 90). They are cylindrical, non-segmented sacks, without lateral diverticula, each lined throughout its length by a thin epithelium (Fig. 83) with much flattened and sparsely distributed nuclei. Externally each is immediately invested by large-celled parenchym (*Par*). In one individual the two testes did not extend forwards for the same distance. These sacks in the free stage of the worm contain spermatozoa, which may entirely fill the lumen;

after the spermatozoa have been discharged, the testes do not collapse but remain of the same volume being firmly held in position by the surrounding parenchym (Figs. 83, 88). In the smaller males found in the free state immature spermatozoa are found in the most anterior region of the testes, and also globular bodies without nuclei. None of the nuclei of the lining epithelium, the germinal epithelium, were found in stages of mitosis.

I have used the name "testis" for the whole extent of each of these sacks, while Vejdovský has termed only the most anterior portion "testis", and the remainder of the sack "Samensack", on account of his discovery that only the most anterior portion produces the sperm cells. I find, however, that each is lined throughout by the same kind of an epithelium, so that if one portion be called testis the whole extent should be. Each is without lateral diverticula, thereby corresponding in appearance to the uteri of the female; we have shown that in the female the paired uteri together with their numerous lateral diverticula must be considered as a pair of ovaries; and the structure in the male is similar, except that the paired testes are without lateral diverticula.

The vasa deferentia. Near the posterior end of the trunk each testis connects with a vas deferens (*Vas* Figs. 80, 81, Pl. 6), a tube of much smaller diameter lined internally by a glandular epithelium (*Vas* Fig. 89, Pl. 7), and externally by a sheath (*Vas. S*) of slender, deep-staining cells arranged concentrically, evidently modified parenchym elements; this sheath is thickest anteriorly where the vas joins with the testis, and does not extend forward of that region. The lumen of the vas is very narrow, and its lining of epithelium often much folded. The cuticula of the cloaca is continued for a very short distance along the posterior end of each vas.

The cloaca. The posterior intestine from the mid line and the vasa deferentia from the sides join posteriorly to form the cloaca (*Cl* Figs. 80, 81, Pl. 6). The cloaca is lined by a cubical epithelium (*Cl. Epi* Fig. 87, Pl. 7) without gland cells, covered by a thin cuticle (*Cl. Cut*). Its anterior portion lies above the cloacal ganglion (*Cl. G*) in the mid-line, surrounded by parenchym; its posterior portion (Fig. 80, Pl. 6, Fig. 86, Pl. 7) bends ventrad and opens on the ventral surface of the body just anterior to the point of junction of the two tail lobes. At this point its epithelium and cuticula pass continuously over into the hypodermis and body cuticula, so that the cloaca probably represents a proctodaeum. Its external aperture is an elongated slit (*Cl.Ap* Figs. 81, 82, Pl. 6), sometimes nearly closed, sometimes widely open. No chitinous spiculum was observed in any individual in the cloaca, but in two a rod-like glandular mass, evidently a secretion from the vasa deferentia. It is probably this secretion, together with that from the anterior portion of the testes, which forms the mucous envelope (*Sp.Secr* Fig. 68, Pl. 5) around the mass of spermatozoa (*Sp*) when in the receptaculum of the female. There is no special cloacal muscular diaphragm such as occurs in *Gordius*. The innervation of the cloaca is close to its external opening, where nerve fibres enter its epithelium from the contiguous neural lamellae of the caudal nerves (Fig. 86, Pl. 7). The genital nerves (*Gen.N* Fig. 89) as previously described, pass from the dorso-lateral angles of the anterior end of the cloacal ganglion (*Cl.G*) into the fibrous sheath (*Vas.S*) around the vasa deferentia (*Vas*).

The mature spermatozoon (Fig. 91, Pl. 7), as found in the receptaculum seminis of the female, appears to be very simple in structure, showing a rod-shaped chromatic head and a long, cytoplasmic flagellum; sometimes the latter appears segmented, but this is probably a dissolution phenomenon; neither acrosome nor middle piece could be distinguished. In an immature male from the body cavity of an *Acheta*, and with thin white cuticle, the testes were relatively much larger than in the free stage of the worm, and filled with what were evidently spermatocytes in the prophase (spirem) of the first maturation division; but the preservation of them was too poor to allow a careful study. In the receptaculum seminis of the female the spermatozoa are enveloped by a thick mucous sheath (*Sp.Secr* Fig. 68, Pl. 5), which we have seen is probably a secretion of the male; this might indicate the formation of a large spermatophore, as has been described by Villot.

Literature on male genital organs. Villot (1874, 1887, 1889c) describes two "tubes testicolaires", each with an inner epithelial lining. He considers the "bursa copulatrix" of Vejdovský (1886) as simply a coagulated mass of spermatozoa (as does von Linstow, and as I also would interpret it). Vejdovský (1886, 1894) describes these tubes as "Samensäcke", and considers that only the anterior end of them should be regarded as "testes", since only here did be find cell formation. von Linstow (1889), on the other hand, finds that in the immature stage the whole wall of the "Hoden" proliferates sperm cells, and that this process proceeds from the posterior towards the anterior end.

Vejdovský is the only one to speak of a chitinous spiculum in the cloaca; but with von Linstow I agree that what he observed was probably a mass of glandular secretion from the wall of the cloaca.

None of the writers have described spermatozoa of elongate form, such as those of *Paragordius.*

XII. Parasites.

Imbedded within the epithelium of the cuticular portion of the cloaca of two individuals were found certain parasites which are probably Coccidia. The following conditions of these parasites were noticed. 1) A rounded or oval cell (Figs. 58, 59, Pl. 4) with a distinctly granular cytoplasm (fixation by 4 % formalin) and very delicate cell membrane, containing one nucleus (*N*); the latter nearly spherical with a thick membrane, and containing a smaller body with a few deep-colored spherules imbedded in it. These were found in the cloacal cells of a worm double-stained with haematoxylin and eosin, yet the substance of the parasites were not colored by either of these stains, the cytoplasmic granules appearing brownish-yellow, the nuclear membrane deep brown and the spherules of the nucleus rather dark and refractive. 2) Conditions more frequent than the preceding, where numerous refractive rods, lumps and threads occupy the greater part of the cell, a small portion of unchanged protoplasm being left at points of the periphery (Fig. 57). The irregular bodies within the cell were brown in color, and were not affected by the double stain. 3) Small rounded and ovoid bodies (Fig. 56) found in the epithelial cells, of the same consistency and color as the bodies found within the cell in the 2nd condition. Perhaps these three conditions represent successive stages in a sporogony, the small rounded bodies in the epithelial cells of the host being then the spores. It is remarkable that no portions of these cells take on the chromatin stain.

In one of the individuals thus infected there were found also in the medio-ventral body cavity, most abundantly near the posterior end of the latter but also scattered along its whole extent, numbers of small floating cells. These are mononucleated rounded cells (Fig. 60), the nuclei (*N*) situated at the surface of the cell body. These nuclei are very variable in shape, sometimes Ushaped, sometimes irregularly lobed, sometimes nearly circular in outline; sometimes the nucleus is fragmented into several portions, sometimes no nucleus at all can be seen. The chromatin stains deeply with haematoxylin, is mainly limited to the periphery, and often shows a vesicular arrangement. The cytoplasm is often finely granular in appearance, sometimes it encloses large, clear vacuoles. There is an evident cell membrane. These cells were not found within the lumen of the intestine or of the genital organs, though some were found imbedded into the surface of the supra-intestinal organ (*Par. N* Fig. 21, Pl. 2). Their occurrence in only one individual shows them to be parasites and not free blood corpuscles; but whether they are particular stages of the parasites found within the cloacal wall remains to be determined. Undoubtedly these parasites are such as usually occur in the last host of *Paragordius*, so that a study of the parasites of *Acheta* would serve to explain their nature.

In one male there was found imbedded in the sheath tissue of the eye a small clear body containing a much curled thick thread that stained deeply with iron-haematoxylin; its appearance was very similar to the fig. 93 given by Schaudinn of the spirem stage of the oocyst nucleus of *Coccidium*[1]).

Literature. No author to my knowledge has described parasites in the Gordiacea.

XIII. On the Relationships of the Gordiacea.

In the following discussion the Gordiacea will be considered from the standpoint of their adult structure alone. While the early development is known to some extent, up to the stage of the larva, and while the immature stage found in terrestrial insects (the stage which immediately precedes that of the mature organisation) has been described, especially by Vejdovský, the long series of changes between these two conditions are as yet unknown. Thus while the adult structure of the genera *Gordius* and *Paragordius* are now known sufficiently well to allow of comparison with other forms, there is a great hiatus in our knowledge of the ontogeny. Until this gap in our knowledge is cleared away by future observations, the embryology can be of but little service in determining the phylogeny. For the stages yet undescribed may be the very ones to prove of most value for this inquiry.

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1) Schaudinn, Unters. über den Generationswechsel bei Coccidien, in: Zool. Jahrb., V 13, Anat., 1900.

The older investigators of the Gordiacea classed them with the Nematoda. The points of structure on which this grouping was made, were: the elongated form, the thick external cuticula, the presence of a single layer of longitudinal muscles, the absence of distinct segmentation, the tubular character of the reproductive organs, and the lack of a blood vessel system. Even to-day in most of the zoological text-books the Gordiacea are classed with the Nematoda together in the group of the Nemathelminthia; by others as no more than a family of the Nematoda. VON LINSTOW (1897) divides the Nemathelminthes into three groups: the Secernentes, the Resorbentes, and the Pleuromyarii, and includes in the latter such heterogeneous forms as *Trichocephalus*, *Trichosoma*, *Gordius*, *Nectonema*, *Mermis* and *Echinorhynchus*. All the various classifications of the Gordiacea under the Nematodes need not be repeated here, since VILLOT (1874), VEJDOVSKÝ (1885) and CAMERANO (1897) have mentioned them in their historical sequence.

A smaller number of authors have questioned the relationship to the Nematodes. Thus VON SIEBOLD (1843) classed the Gordiacea as an independent order equivalent to that of the Nematodes. GRENACHER (1868) with his usual critical acumen also emphasized the great degree of structural difference between these groups. Then VILLOT (1874) concluded that it is necessary to establish for the Gordiacea a special order, to be placed at the head of the class Helminthes; but he later (1881) referred them to the Nematodes. VEJDOVSKÝ (1886) concludes that they are "degenerirte Annulaten ... und vorläufig als eine selbständige Ordnung der Nematomorpha zu unterscheiden"; and in 1894 he states: "Ueber die verwandtschaftlichen Beziehungen der Gordiiden zu andern Wurmgruppen darf man sich erst dann bestimmter aussprechen, wenn die eigentliche Larve (der Embryo der Autoren) genauer in ihren Organisationsverhältnissen bekannt ist". CAMERANO (1897) makes two orders of the Nemathelminthes, the Nematodi and the Gordiacei, the latter comprising the two families Nectonemi and Gordiidi, the phylum of the Nemathelminthes and that of the Annelida connecting only at their roots (in the group of the Provermalia).

We have accordingly to consider whether the Gordiacea show affinities to the Nematodes or to the Annelida, or whether they should be considered an independent phylum; for possible relationships with any other living groups are too vague to be treated. We have to do with interpretations of adult structural resemblances, since the most important stages of the ontogeny are unknown; discussions of general form and mode of life are here not decisive.

The hypodermis with its thick cuticula resembles that of the Nematoda; such a cuticula has been independently acquired, however, by such diverse groups as the Nematodes, Trematodes, Acanthocephala, Chaetognatha, and Arthropoda, it is a structure quite generally produced by endoparasitic and terrestrial modes of life, and hence is of little importance in considering relationships. Consideration of the intestinal system is of almost equally small value.

The absence of a blood vascular system is a character shared by all Nematoda, while all free-swimming Annelida have such an organ system. But this also is a character of variable value: one need but recall the great modifications of the vascular system within such a narrowly circumscribed group as the Vertebrata, or as in the Annelida, Nemertini and Mollusca. Change of mode of life, relative mode of development of other organ systems such as the body cavities and the nephridial system, all influence the vascular system, so that one is hardly justified in placing reliance upon it as a guide.

The body muscle tube is composed of a layer of longitudinal fibres alone. The Nematoda have also only a longitudinal musculature. But some Annelida also have only this layer, thus in *Polygordius* there is no circular musculature (VILLOT). Certainly with a thick and resistent cuticula such as the Gordiacea have, a circular muscle layer could have no functional value, and hence would not be present. VEJDOVSKÝ has pointed out that the Gordiacean muscle cells are formed upon the same plan as those of Annelida, with a non-contractile core and a rind of contractile fibrils, and they do not show the projecting cell bodies so characteristic of Nematodan fibres. I can add another point in which these fibres differ from those of Nematoda: the innervation, in all probability, is from their outer, hypodermal surface, and not from their inner. Thus the muscle structure is of an essentially different type from that of Nematoda, and similar to that of Annelida.

The nervous system of the Gordiacea consists of a ventrally placed nerve cord, with an anterior enlargement, the cephalic ganglion, and a posterior one (more marked in the female), the cloacal ganglion. In the cephalic ganglion there is a ventral fibrous commissure beneath the oesophagus, but no nerve cells lie above this commissure, therefore there is no cerebral ganglion; in *Gordius* there is a supra-oesophageal fibrous commissure, in *Paragordius* this is represented by a pair of large nerves which penetrate the capsule of the eye and ramify there. There is thus no ring of nerve cells around the oesophagus as in the Nematoda, nor yet a cerebral ganglion as in the Annelida; but the anterior end of the central nervous system is on the whole unique in its structure. The ventral nerve cord is connected with the underlying neural lamella, through which nerve fibres pass to the hypodermis. Vejdovský found that in *Gordius* this lamella is more or less interrupted, but in *Paragordius* I find it to be a continuous, unbroken lamella beneath the whole extent of the nerve cord. There are thus no segmental attachments of it to the hypodermis, and the nerve fibres within it are neither paired nor segmentally arranged. The nerve cells also (of which there are two kinds) of the central nervous system do not show a paired distribution nor segmental arrangement (in the form of ganglia), but succeed each other continuously along the whole extent of the cord. The adult structure shows the nerve cord to be an unpaired and unsegmented structure, with the nerve cells arranged ventrally and laterally, and with one unpaired and three paired fibre tracts; and Vejdovský from embryological studies regards the first origin of the nerve cord as unpaired. Thus the type of the nervous system is entirely different from that of the Annelida. It differs also from the Nematodan nervous system in that in the latter there are (at least in the anterior portion of the body) two median and two lateral nerve trunks. The fact that the Gordiacean nerve cord shows a more or less tripartite structure would suggest that it might represent a possible coalescence of a ventral with a pair of lateral nerve trunks, and thus be referable to the Nematodan type; but this is improbable, for the neural lamella connecting with the hypodermis is a strictly unipartite structure. The occurrence of true nerve cells in the hypodermis, particularly in the dorsal region, shows the nervous system to be of rather a diffuse type; and in general it may be considered unique, and not referable to that of Annelida or Nematoda.

We now come to an organ system that has gradually come to be regarded as of great importance in anatomical comparisons, the genital system. In the Nematoda the essential organs are, in the female, a pair of long, non-segmented tubes, the ovaries, and of continuations of the latter, the oviducts, which open by means of an unpaired vagina generally on the ventral surface of the body at a considerable distance anterior to the anal aperture; in the interesting genus *Cloacina* alone, as described by von Linstow (1897b), does the uterus join with the intestine to compose a cloaca. In the males of the Nematoda there is generally an unpaired, tubular, non-segmented testis which opens into a cloaca; but in some forms, according to Bütschli (1874), there is a pair of testes. In the Annelida, on the other hand, the ovaries and testes are not tubular organs, they also do not connect with the intestine, but are proliferations, often but not always metameric in arrangement, of the peritoneum; the germ cells from these centres of growth fall into the coelom, and from there arrive at the exterior either by way of nephridia (or modified nephridia), or else by rupture of the body wall. Now in the Gordiacea there are paired, tubular genital organs in both sexes, opening into a cloaca. In the male the structure is simpler: a pair of long, completely closed, non-segmented tubes, the testes (Vejdovský terms only their anterior ends testes), lined by a germinal epithelium. Here is then a great similarity to the case of those Nematoda with a pair of testes. In the female of the Gordiacea occur, in addition to the pair of long uteri (which seem in position comparable to the testes of the male), also numerous paired sacks lying in the lateral body cavities and each connected by an opening with the cavity of the uterus of the corresponding side of the body. Vejdovský first showed these sacks (his "Eiersäcke") to be segmentally arranged, and that each developes as an evagination of the wall of a uterus. On account of such segmentally arranged "Eiersäcke", and their first beginnings, the "Eierstöcke", Vejdovský concluded the ovaries of the Gordiacea to be bilaterally and segmentally arranged, and so to agree with the Annelidan type. But in the descriptive part of this paper I have given reasons for concluding that the uteri together with these Eiersäcke must be considered as composing a single long pair of ovaries, that is, a pair of ovaries each with numerous lateral diverticula. For both are lined by the same kind of epithelium; the cavities of the lateral diverticula (at least in *Paragordius*) communicate only with the cavities of the uteri, and not into the lateral body cavities; and the points of proliferation of the ova are where the diverticula first arise as outgrowths from the walls of the uteri, so that the germinal epithelium is as much part of the so-called uteri as of the so-called ovaries. The term "ovary" in the strict sense of course signifies the place where the growth of ova takes place; but in general usage it means also the place characterised by the presence of a germinal epithelium, whether all portions of this epithelium proliferate ova or not. Vejdovský himself has shown (1894) that at an early stage the whole lining of the uteri produce ova; and even though such ova degenerate, and the definitive ova are produced only within the diverticula, this is sufficient to show the physiological correspondence of the uteri and the diverticula (ovaries in the narrow sense). In the Gordiacea then, there are a pair of long tubular ovaries (or uteri in the narrow sense), with numerous strictly paired diverticula (ovaries in the narrow sense); these diverticula are so numerous (3000 to 4000 on each side in an adult *Paragordius*) that they cannot be called metameric, for we know no animal forms comprising so many metameres (here the Cestoda are not considered).

In respect to the genitalia, accordingly, the Gordiacea resemble much more the Nematoda than the Annelida: they are essentially tubular and non-metameric. And until it can be shown that the cavity of these tubular testes and ovaries is a portion of a true coelom, there can be no true comparison with the Annelida; indeed the anatomial relations of the adult, and Vejdovský's own interpretations of the nature of the body cavities proper of the Gordiacea, would show the cavities of the genitalia to be extra-coelomic.

As to the body-cavities, there are found in both sexes a mediodorsal and a medio-ventral cavity, and in the female a pair of lateral cavities; in the female these spaces are separated by two dorso-ventral mesenteries, and the dorsal and ventral divergence of these mesenteries occasions the median cavities, and each mesentery embraces a uterus. Each lateral body cavity is bounded by a layer of parenchym termed by Vejdovský "peritoneum", by me "perienteric membrane". Now undoubtedly such relations are not found in the Nematoda, where there are no mesenteries and where the body cavity has no proper cellular lining. Vejdovský finds in these cavities, at least in the lateral ones, homologa of the coelomic sacks of Annelida, and he compares the mesenteries directly with those of Annelida. But there is an important difference in the Gordiacea: the lateral cavities are not segmented in any way nor are they transversed by dissepiments; and while each lateral cavity has a cellular lining (laterally the perienteric membrane and medially the wall of a mesentery) the germinal epithelium does not come from this lining, but from the internal wall of the uterus which is entirely closed from these lateral cavities. Further, the mesenteries do not embrace the intestine closely, but are widely separated from it. These are differences of considerable importance, and though Vejdovský's interpretation of these cavities was very acute and suggestive, it is in my opinion by no means probable that the mesenteries and lateral cavities are to be compared with the mesenteries and coelomic sacks of the Annelida. This point must be finally decided from the standpoint of the development, in early stages which have not yet been described.

On account of these differences between the Gordiacea and the Annelida I have adopted the indifferent term "parenchym" for the tissue which lines the body cavities, not wishing to employ the term "peritoneum" which in the strict usage denotes the lining of a proved coelom. It is on the whole a unique kind of tissue, in the adult composed of cell bodies firmly united together by a dense intercellular substance, and its cells are not free. VEJDOVSKÝ holds that it is formed late in the ontogeny, as a proliferation of the primitive lining of the body cavity, and considers it to be lymphoidal.

As to excretory organs, there are in the Nematoda a single or a pair of unicellular nephridia placed in the so-called lateral lines, which open together in the mid-ventral line of the head region. In the Annelida there are usually metamerically arranged metanephridia, or sometimes these connected by a longitudinal duct (*Lanice*). Neither of these conditions are found in the Gordiacea. VEJDOVSKÝ has interpreted the medio-ventral body cavity (periintestinal space) as an excretory organ; it has, however, no opening to the exterior. In immature stages he found in the anterior portion of this space a "braune Drüse" opening into the intestine near the mouth. Under the name "supra-intestinal organ" I have described a long unpaired canal lying upon the dorsal side of the intestine in *Paragordius*, and having lateral diverticula; this may be an excretory organ, conveying fluids from the periintestinal space to the intestine, but whether it is homologous with the "braune Drüse" of *Gordius* remains to be determined. Both these organs are unpaired, in close attachment with the intestine, and without any opening to the exterior; they cannot be at all compared to the nephridia of Nematoda or Annelida, and appear to be degenerate in the adult condition. Whether the oviducts and vasa deferentia may be modified nephridia, as VEJDOVSKÝ suggests, depends upon their mode of origin, which is unknown; there is a structural character to speak against this view, namely that the epithelial lining of these ducts is similar to that of the uteri and testes, which would necessitate the genital organs in their full extent being modified nephridia.

Finally some comparisons of minor importance may be made. There are in the Gordiacea no appendages nor any signs of such

e. g. in the arrangement of the musculature, nor yet any signs of setal sacks. The only ciliation in *Paragordius* is found in the oviducts: the Nematoda have no ciliation, the Annelida are usually richly ciliated. The spermatozoa are elongate and hair-shaped, not amoeboid as in the Nematoda.

Summary. With the Nematoda the Gordiacea have in common only one important structure, the tubular genitalia and their opening into the cloaca. With the Annelida they agree in the structure and innervation of the musculature, and in having dorsoventral mesenteries which divide body cavities bounded by cell layers. But there is good reason for doubting the homologies of these mesenteries and body cavities in these two groups of animals. They differ from the Annelida in showing no trace at all of true metamerism (either in the nervous system, the body cavities, the genitalia or the body wall); in the absence of a cerebral ganglion, of a vascular system, of setal sacks or extremities; and very markedly in the structure of the genitalia. In view of these facts the Gordiacea cannot be regarded as even highly degenerate Annelida, as VEJDOVSKÝ has done, nor yet as modified Nematoda, the view of most of the writers, but must rather be considered a group of isolated position, as GRENACHER, VON SIEBOLD and VILLOT have regarded them.

The group of the Gordiacea contains three well defined genera: *Gordius*, *Paragordius* and *Chordodes*; until the structure of *Chordodes* is better known their relationships to each other cannot be determined. As to the marine worm *Nectonema agile* VERRILL, while, as WARD (1892) has shown, it approaches closer to the Gordiacea than to the Nematoda, yet there are still some important differences between it and the former group, such as the brain appearing to have a dorsal ganglion, in the absence of mesenteries, and in that the sack containing the spermatozoa in the male (testis?) is unpaired; BÜRGER (1891) has shown that the musculature appears to be of the Nematodan type. In view of these differences, and of the very incomplete state of our knowledge as to the genitalia, we are hardly justified in grouping *Nectonema* with the Gordiacea, as CAMERANO has done.

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Explanation of Plates.

Plates 1—7.

All the figures have been drawn with the aid of the camera lucida. The following abbreviations have been employed in the lettering of the Figures:

A. Cut areolar layer of outer cuticula
Ar areole of outer cuticula
Atr atrium
B. M basement membrane
Cd. N caudal nerve
Ceph. G cephalic ganglion
Ceph. N cephalic nerve
Chb. C chromophobic nerve cell
Chb. N chromophobic nerve fibre
Chl. C chromophilic nerve cell
Chl. F chromophilic nerve fibre
Chl. N nucleus of chromophilic nerve cell
Cil ciliary tuft
Cl. Ap cloacal aperture
Cl. Cav cloacal cavity
Cl. Cut cloacal cuticula
Cl. Epi cloacal epithelium
Cl. G cloacal ganglion
Cl. N cloacal nerve
Cu. Cl cuticular region of cloaca
Cut cuticula of body wall
Dors. N dorsal nerve of cephalic ganglion
Dors. N. B branch of dorsal nerve of cephalic ganglion
D. T dorsal nerve fibre tract of nerve cord
D. T. L dorsal tail lobe
E. Cap eye capsule
E. Cap. C cell of eye capsule
E. Cav fluid cavity of eye
E. Coag coagulated fluid of eye cavity
E. Hyp anterior hypodermal wall of eye
E. Hyp. C hypodermal cell of eye
E. Hyp. C. 2 rounded cell of hypodermis of eye
F. Cut fibrous (inner) layer of cuticula
Gen. N genital nerve of male
G. Epi germinal epithelium
Gl. C gland cell
Gl. Cl glandular region of cloaca
Gl. Secr glandular secretion
H. Cut homogeneous layer of outer cuticula of body wall
Hyp hypodermis
Hyp. N nucleus of cuticular cell of hypodermis
I. M. S intermuscular tissue
Int intestine
Int. S sheath of intestine
L. Cav lateral body cavity
L. H. N longitudinal nerve of hypodermis
L. Par large-celled parenchym
L. T. L lateral tail lobe
L. V. T latero-ventral fibre tract of nerve cord

M. D. Cav	medio-dorsal body cavity
Mes	dorso-ventral mesentery
Mo	mouth
M. T	median fibre tract of ventral nerve cord
Musc	musculature of body wall
Musc. C	muscle cell
M. V. Cav	medio-ventral body cavity
M. V. T	medio-ventral fibre tract of nerve cord
N	nucleus
N. 2	ventral nerve of head
N. C	ventral nerve cord
N. C. Com	transverse fibrous commissure of nerve cord
N. L	neural lamella
N. Sept	neural septum of cephalic ganglion
O	ovum
O. Cut	outer layer of cuticula of body wall
Oes	oesophagus
Ov	ovarium
Ovi	oviduct
Pa	parasite
Par	parenchym
Par. N	nucleus of parasitic organism
P. Cl	black region of cuticular portion of cloaca
P. Cl. N	posterior cloacal nerve
Per. M	perienteric membrane
P. Int	posterior intestine
Rec	receptaculum seminis
Ret	retina
Ret. C	retinal cell
R. Musc	radial musculature of stomach region
Rec. N	neck of receptaculum seminis
Sen. C	sensory cell of hypodermis
S. I. O	supraintestinal organ
Sp	spermatozoa
S. Par	small-celled parenchym
Sp. Secr	secretion mass around spermatozoa
Stom	stomach
Tes	testis
T. L	tail lobe
Tub	cuticula tubercle
Ut	uterus
Vac	vacuole
Vas	vas deferens
Vas. Ap	opening of vas deferens into cloaca
Vas. S	fibrous sheath of vas deferens
V. Com	ventral commissure of cephalic ganglion
X	sack-shaped organ of doubtful significance
Yk	yolk globule

Plate 1.

Fig. 1. Male, left side of the end of the head posteriorly to the commencement of the black cervical ring, cleared in cedar oil. 255 : 1.

Fig. 2. Female, reconstruction of the head in the median plane; all organs of the mid line shown except the parenchym; in dotted lines organs not in the mid line. 75 : 1.

Fig. 3. Male, similar reconstruction; the unpaired neural septa are in dark, the paired in light shading. 142 : 1.

Fig. 4. Female, head from the left side shown as far back as the black cervical ring, cleared in cedar oil. 75 : 1.

Fig. 5. Female, portion of transverse section through the ventral portion of the eye capsule and the retina, showing two branches of the dorsal nerves (of the cephalic ganglion) passing dorsally through the eye capsule to the retinal cells. 848 : 1.

Fig. 6. Male, slightly oblique median section of head to one side of the median plane. 255 : 1.

Fig. 7. Female, reconstruction of the head end in the horizontal plane, viewed from the dorsal aspect, oesophagus not shown.

Fig. 8. Female, a tuft of retinal cells attached to a cell of the eye capsule. 848 : 1.

Fig. 9. Male, portion of a section through the anterior hypodermal wall of the eye, the section paratangential to the surface of the cuticula, and so cut that of the hypodermal cells the uppermost ones are cut close to the surface of the cuticula, the others at gradually deeper levels. 848 : 1.

Figs. 10, 11. Male, longitudinal sections of hypodermal cells of the eye, in both the free ends of the cells pointing towards the bottom of the plate, in Fig. 10 the attached cuticula shown. 848 : 1.

Fig. 12. Female, reconstruction of the supra-intestinal organ, the anterior end of the organ towards the upper side of the plate, to show the arrangement of its lateral branches which are represented as if they projected at right angles from the longitudinal duct instead of being curved around the intestine; the comparative thickness of the different portions not shown. 15 : 1.

Fig. 13. Female, left half of a cross section of the head in plane *D* of Fig. 2 of the preceding plate, showing the first median nervous septum and the second ventral nerve. 255 : 1.

Fig. 14. Right half of section of the same individual, in the plane *B* of Fig. 2. 255 : 1.

Plate 2.

Fig. 15. Ventral portion of cross section of the head of the same individual, in the plane *E* of Fig. 2, showing the second ventral nerve and the left nervous septum of the first pair. 255 : 1.

Fig. 16. Portion of cross section of the head of the same individual, in plane *A* of Fig. 2. 255 : 1.

Fig. 17. Portion of cross section of the head of the same individual in plane *C* of Fig. 2. 255 : 1.

Figs. 18—21. Cross sections through different regions of the supra-intestinal organ, showing its apposition to the intestine. 848 : 1.

Fig. 22. Female, cross section of the nerve cord and hypodermis in the anterior region of the trunk; the cytoplasmic structure of the hypodermis somewhat diagrammatized. 848 : 1.

Fig. 23. Male, transverse section of cephalic ganglion in the plane of the ventral commissure. 848 : 1.

Fig. 24. Female, transverse section of the nerve cord and ventral hypodermis of the anterior trunk region. 848 : 1.

Fig. 25. Female, transverse section of nerve cord and contiguous body wall, the cuticula not drawn. 848 : 1.

Plate 3.

Fig. 26. Male, transverse section of nerve cord near its anterior end. 848 : 1.

Figs. 27, 28. Female, transverse sections of the ventral hypodermis at the point of attachment of the neural lamella, in the most anterior trunk region; in Fig. 28 the ground substance of the hypodermis not shown. 848 : 1.

Figs. 29, 30. Chromophobic nerve cells of the cephalic ganglion. 848 : 1.

Fig. 31. Male, slightly oblique vertical longitudinal section of the nerve cord and neural lamella, from the most anterior trunk region; the upper part of the section lies to one side of the mid line. 848 : 1.

Fig. 32. Female, horizontal longitudinal section of the nerve cord at the middle plane of its height. 528 : 1.

Fig. 33. Female, horizontal longitudinal section of the neural lamella, close to its insertion upon the hypodermis; the straight lines represent the boundaries of the contiguous musculature. 848 : 1.

Fig. 34. Male, portion of a longitudinal section of the anterior wall of the head, showing hypodermal elements; the cuticula not drawn. 848 : 1.

Fig. 35. Male, portion of a longitudinal section of the latero-anterior wall of the head, showing the ending of a cephalic nerve in the hypodermis; the cuticula lies contiguous to the left hand surface. 848 : 1.

Fig. 36. Female, cross section of cloacal ganglion, cloacal wall and ventral hypodermis. 528 : 1.

Fig. 37. Female, cross section of the body wall of the left side of the middle trunk region. 848 : 1.

Fig. 38. Longitudinal section of a muscle cell, showing the nucleus in its entire length. 848 : 1.

Fig. 39. Female, apparently bipolar chromophobic nerve cell from the dorsal hypodermis of the trunk; hypodermis shown only in outline. 848 : 1.

Fig. 40. Female, tangential section of the fibrous layer of the cuticula of the middle trunk region, showing its two deepest fibre layers and outlines of hypodermal nuclei beneath them; the axis of the arrow marks the long axis of the body. 848 : 1.

Fig. 41. Female, cross section of the cuticula and hypodermis of the outer wall of a lateral tail lobe, near its posterior end. 848 : 1.

Fig. 42. Female, cross section of the dorsal body wall, with a portion of the mesentery and uterus of the left side. 848 : 1.

Fig. 43. Male, cross section of ventro-median side of a tail lobe near its posterior end, the dorsal surface to the right; details of the fibrous layer of the cuticula not shown. 848 : 1.

Fig. 44. Male, cross section of homogeneous layer of cuticula with a compound tubercle. 848 : 1.

Fig. 45. Female, germinal epithelium of the posterior region of the uterus. 848 : 1.

Plate 4.

Fig. 46. Male, cross section of the hypodermis of the median surface of a tail lobe in its posterior third, at the point where the caudal nerve divides into two; the dorsal surface uppermost. 848 : 1.

Fig. 47. Male, cross section of the medio-ventral wall of a tail lobe in its anterior second-fifth. 848 : 1.

Fig. 48. Female, portion of cross section through the wall of the glandular region of the cloaca, in an ovipositing individual. 528 : 1.

Fig. 49. Female, portion of a section of the wall of the posterior end of the horizontal region of the oviduct. 848 : 1.

Fig. 50. Female, segment of a cross section through the most anterior portion of the cuticular cloaca, the lumen of the cloaca towards the upper side of the plate. 848 : 1.

Fig. 51. Female, portion of cross section of the wall of the atrium, showing one tuft of gland cells. 528 : 1.

Fig. 52. Male, cross section of cuticula at the cloacal aperture, the layers of the fibrous cuticula not shown. 848 : 1.

Fig. 53. Female, cross section of the wall of the receptaculum seminis. 848 : 1.

Fig. 54. Female, portion of cross section of the cuticular cloaca. 848 : 1.

Fig. 55. Female, large-celled parenchym from the anterior trunk region. 848 : 1.

Fig. 56. Female, parasites (spores of Coccidia?) from the cloacal epithelium. 848 : 1.

Figs. 57—59. Female, Coccidium (?) from cloacal epithelium. 848 : 1.

Fig. 60. Parasites from the medio-ventral body cavity of a female. 848 : 1.

Fig. 61. Female, cross section in the plane of the 4th most anterior pair of ovaries. 255 : 1.

Fig. 62. Female, dorsal view of the anterior trunk region, cleared in cedar oil, showing the most anterior pairs of ovaries, the most anterior towards the upper side of the plate. Low magnification.

Fig. 63. Female, portion of a cross section just in front of the anterior end of the receptaculum seminis, of an individual which had discharged most of its ova. 140 : 1.

Fig. 64. Portion of a cross section of an ovipositing female in the middle of the trunk. 140 : 1.

Plate 5.

Fig. 65. Female, portion of a transverse section of the anterior trunk region. 140 : 1.

Fig. 66. Female, cross section of the posterior trunk region before the commencement of oviposition. 142 : 1.

Fig. 67. Female, sagittal longitudinal section of uterus and ovaries of one side, during oviposition. 57 : 1.

Fig. 68. Female, portion of cross section in the plane of the last pair of ovaries during oviposition. 140 : 1.

Fig. 69. Ovum from ovary just before the commencement of the maturation. 848 : 1.

Fig. 70. Female, cross section in the plane of the neck of the receptaculum seminis; the large unlettered space in the left portion of the section is an artefact. 140 : 1.

Fig. 71. Female, cross section of the tail lobes near their posterior ends, the dorsal one uppermost. 140 : 1.

Fig. 72. Female, portion of cross section in the plane of the cloacal ganglion. 140 : 1.

Fig. 73. Female, cross section at the point of junction of the three tail lobes, the dorsal lobe nearest the upper side of the plate. 140: 1.

Fig. 74. Female, cross section in the plane of the posterior end of the atrium. 140 : 1.

Fig. 75. Female, portion of cross section in the plane where the oviducts unite with the atrium. 140 : 1.

Plate 6.

Fig. 76. Female, outline of the ventral wall of the cloaca, to show a chromophilic and a chromophobic nerve fibre passing together from the cloacal ganglion into the cloacal epithelium; the lower side of the figure marks the position of the ganglion, the right side of the figure is dorsal. 848 : 1.

Fig. 77. Female, portion of cross section of the trunk at the end of oviposition, showing a single empty ovary of lobular form attached to the mesentery. 528 : 1.

Fig. 78. Posterior region of an ovipositing female with considerably shrunken ovaries, seen from the left side and cleared in glycerine. 28 : 1.

Fig. 79. Female, reconstruction in the median plane of the atrio-cloacal region. 75 : 1.

Fig. 80. Male, reconstruction of posterior end of trunk and of right tail lobe, in the former parts not in the median line are represented by dotted lines; parenchym not drawn. 142 : 1.

Fig. 81. Male, reconstruction in the horizontal plane of the posterior end of the same individual. 142 : 1.

Fig. 82. Male, ventral view of posterior end. 57 : 1.

Fig. 83. Male, cross section of anterior trunk region, the testes empty. 255 : 1.

Plate 7.

Fig. 84. Male, cross section of the posterior region of the trunk, the testes filled with spermatozoa. 255 : 1.

Fig. 85. Male, cross section of a tail lobe about its middle point, dorsal side towards the top and median side towards the left of the plate. 255 : 1.

Fig. 86. Male, portion of cross section in the plane of the cloacal aperture. 255 : 1.

Fig. 87. Male, portion of cross section in the plane of the cloacal ganglion, the nuclei in the latter are those of chromophobic nerve cells. 255 : 1.

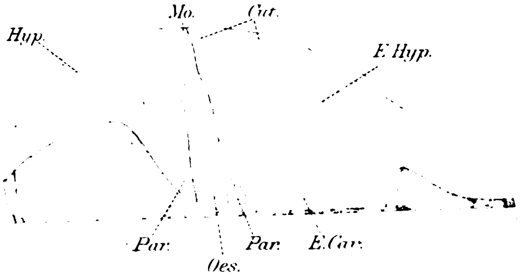
Fig. 88. Male, portion of cross section of the posterior trunk region, near the posterior end of the medio-ventral body cavity. 255 : 1.

Fig. 89. Male, cross section near the posterior end of the cloacal ganglion. 528 : 1.

Fig. 90. Male, cross section in the plane of the anterior ends of the testes. 255 : 1.

Fig. 91. Mature spermatozoon from the receptaculum seminis of a female. 848 : 1.

Frommannsche Buchdruckerei (Hermann Pohle) in Jena.



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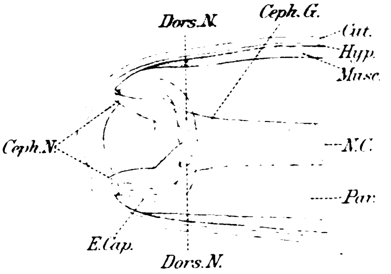

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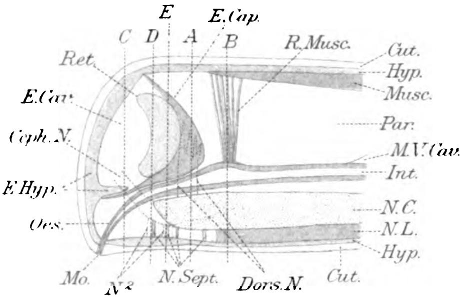

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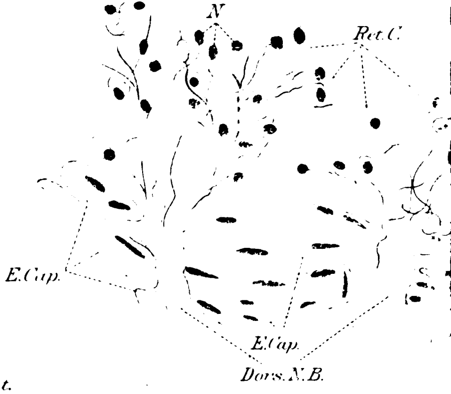

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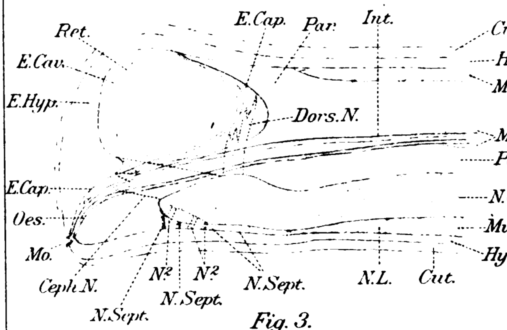

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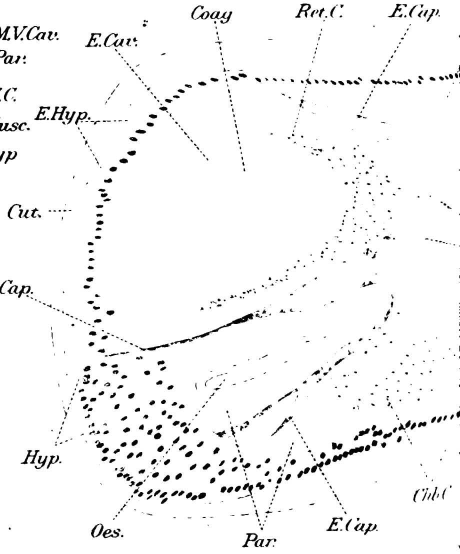

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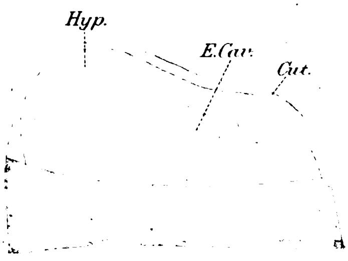

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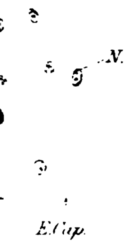

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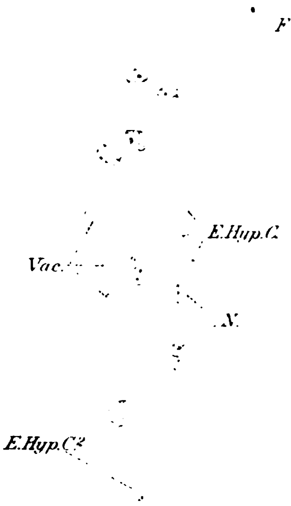

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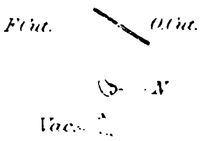

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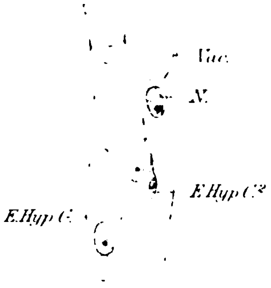

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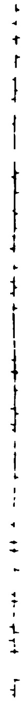

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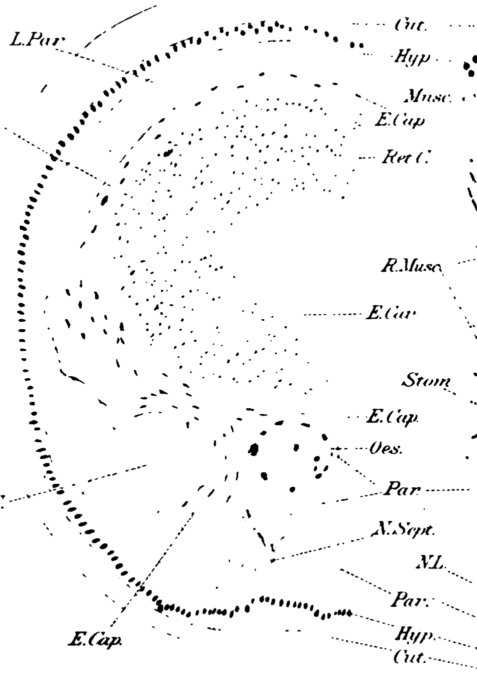

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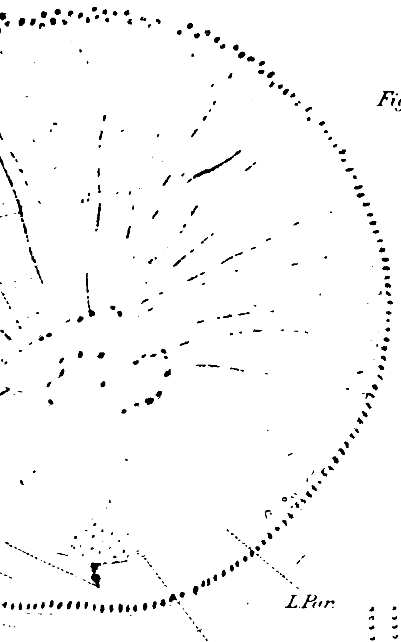

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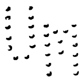

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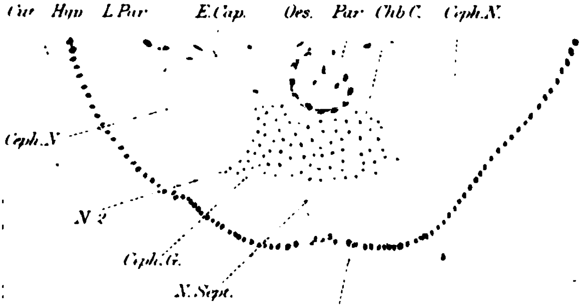

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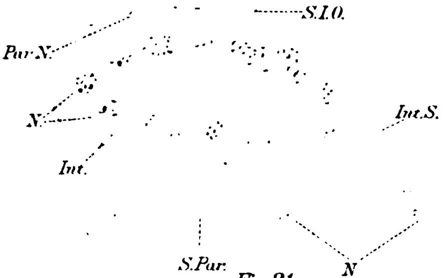

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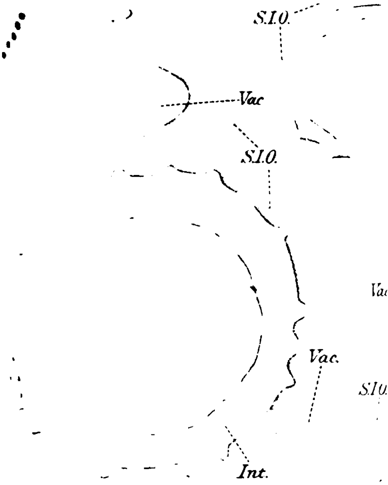

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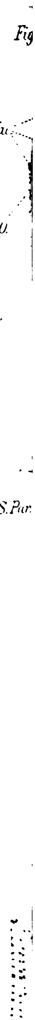

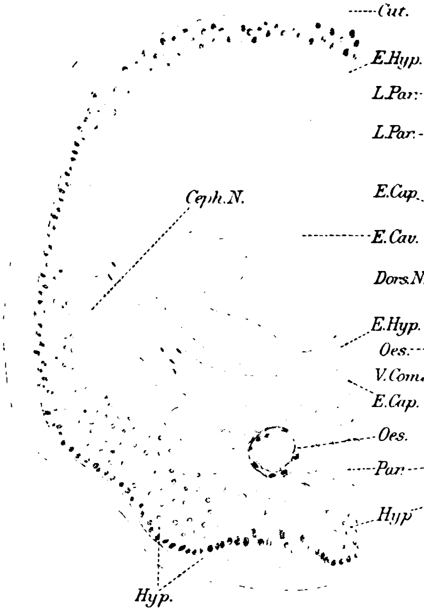

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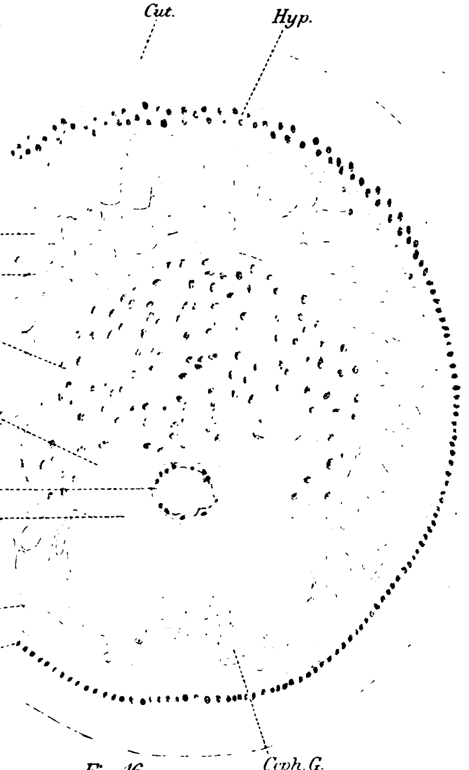

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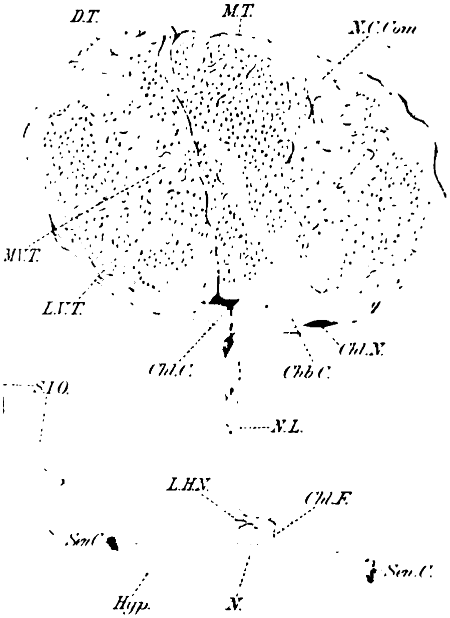
Montgomery gez



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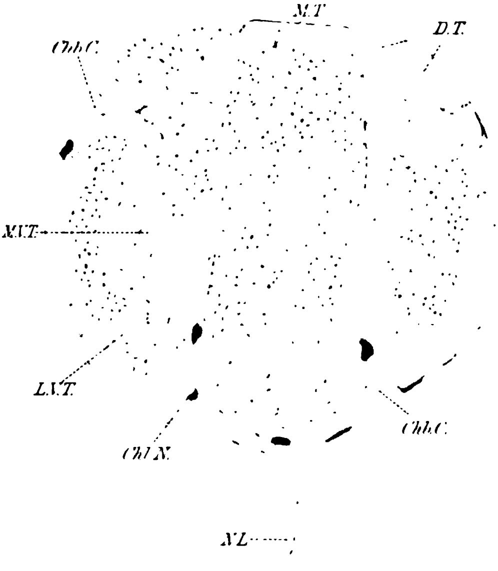

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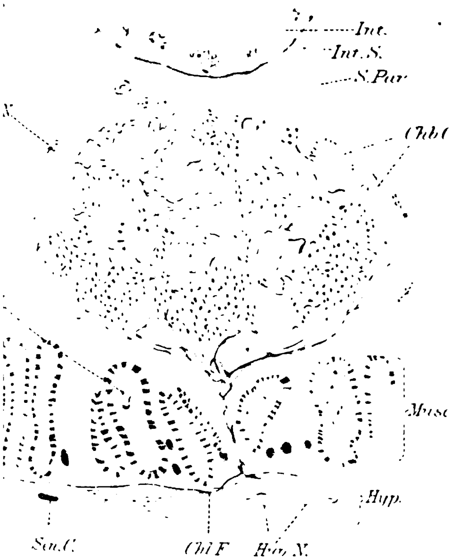

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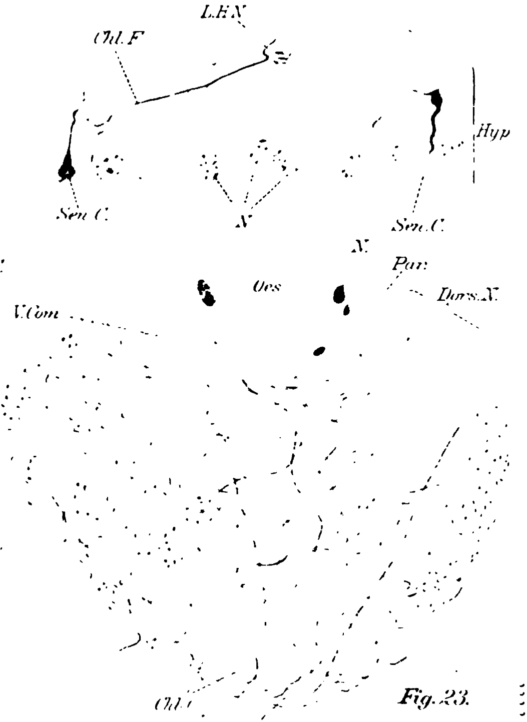

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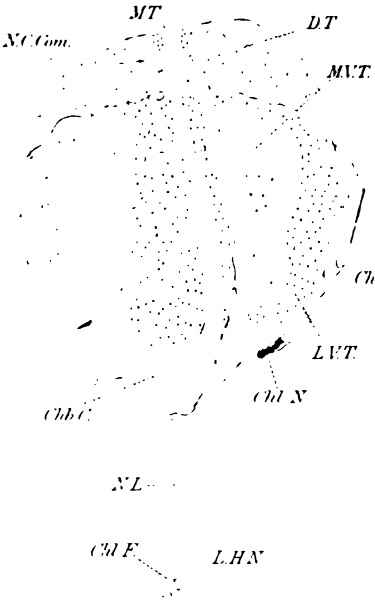

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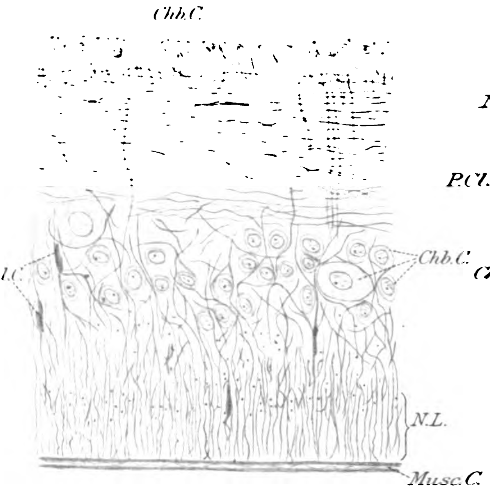

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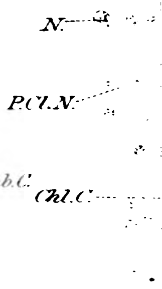

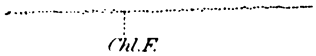

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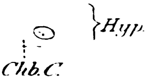

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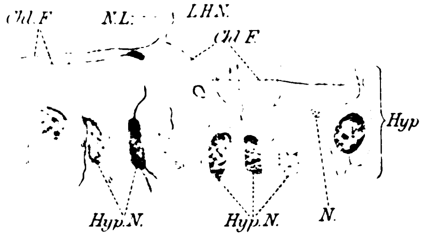

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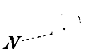

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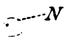

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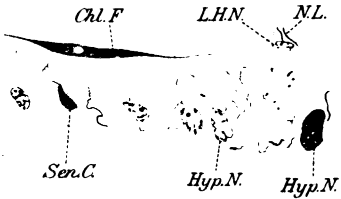

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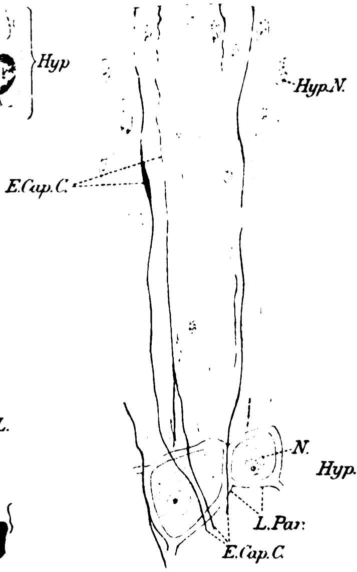

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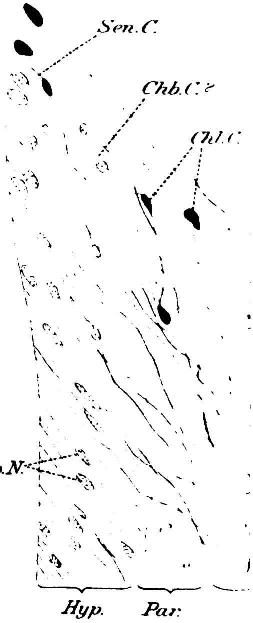

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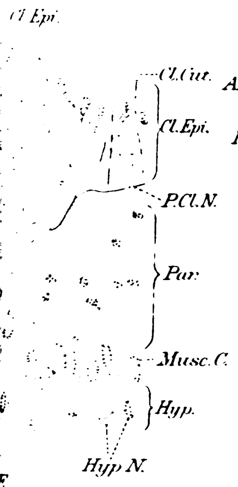

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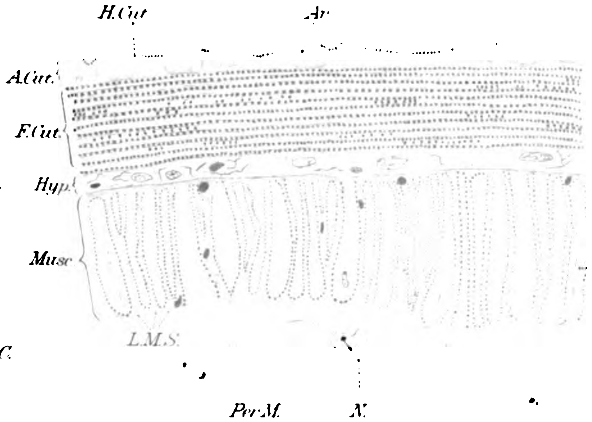

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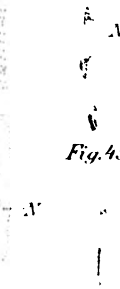

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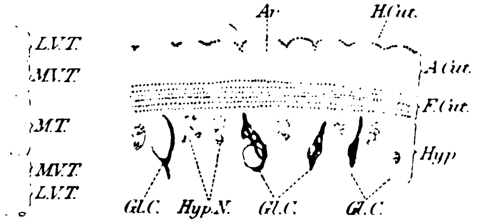

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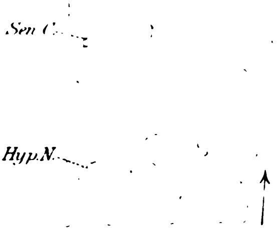

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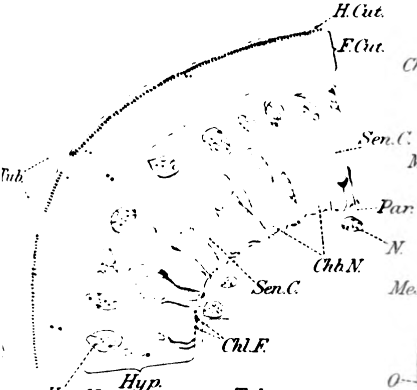

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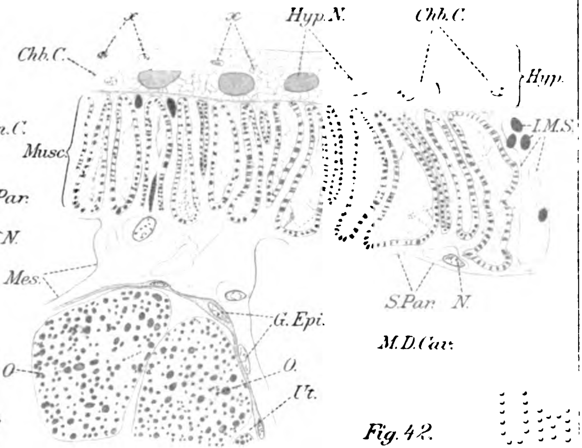

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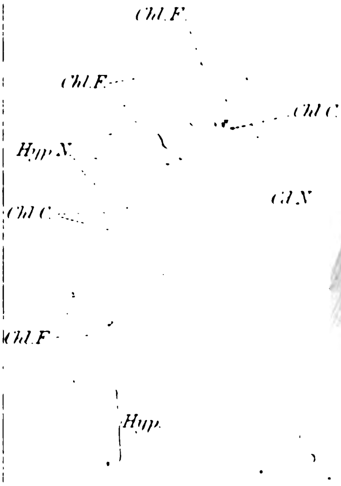

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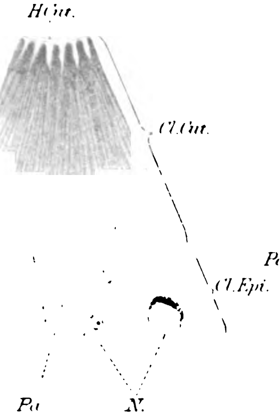

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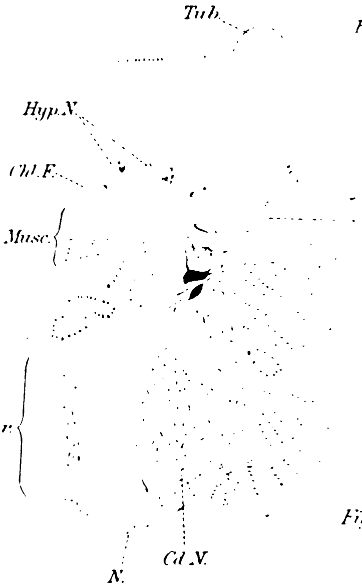

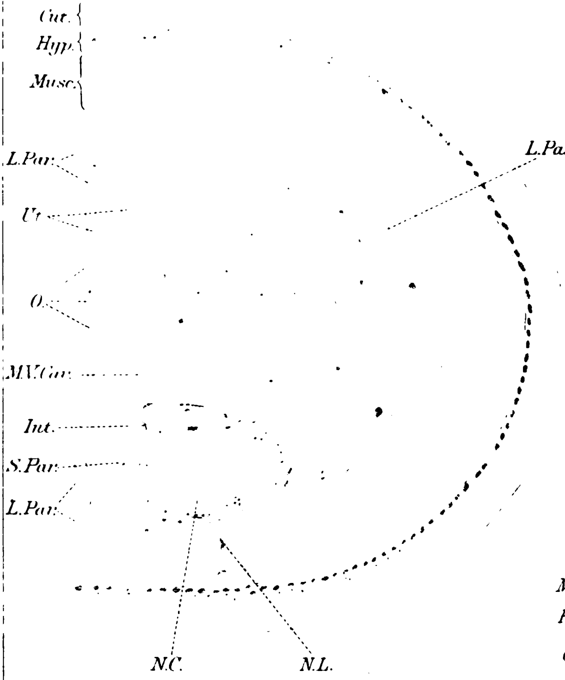

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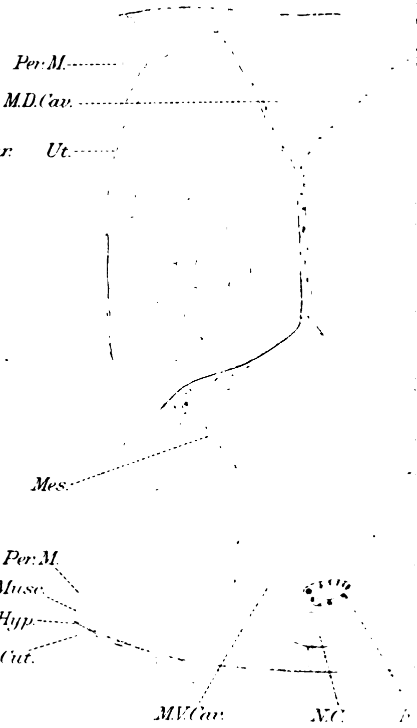

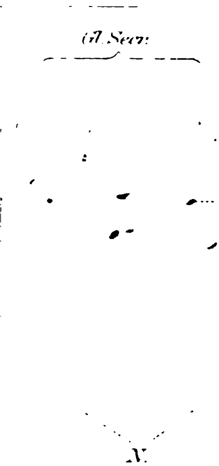

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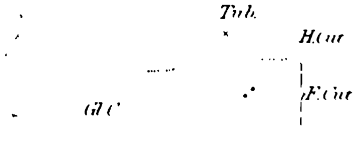

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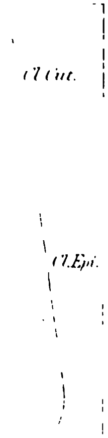

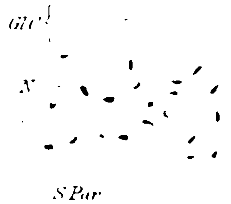

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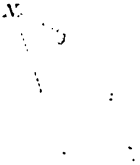

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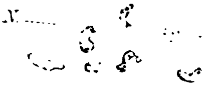

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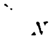

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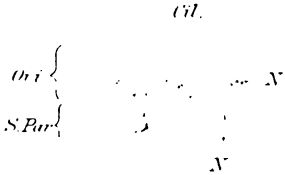

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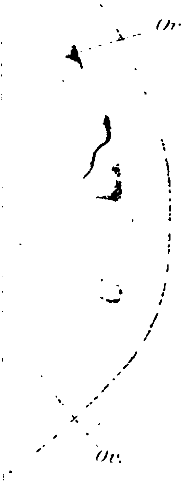

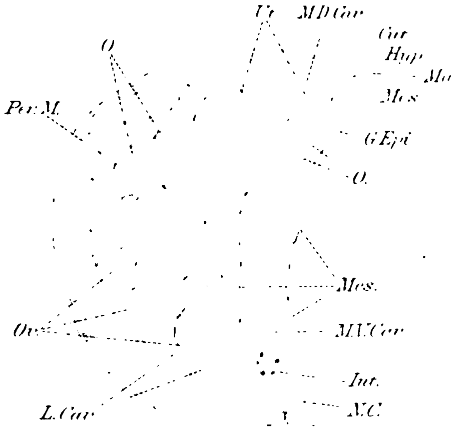

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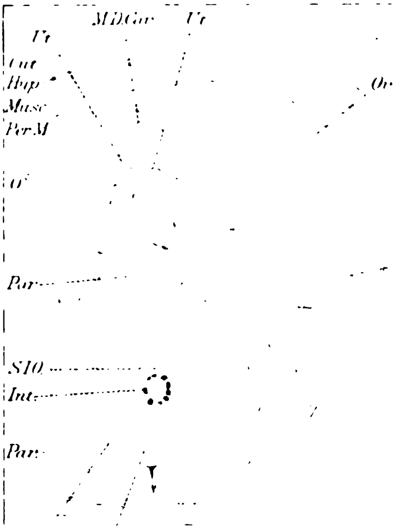

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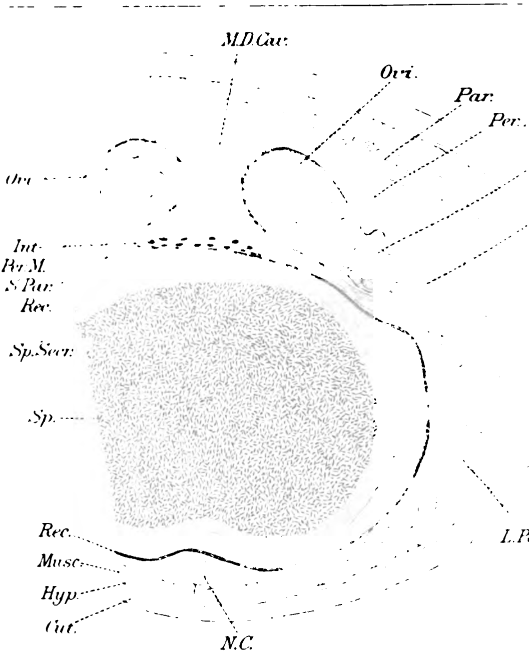

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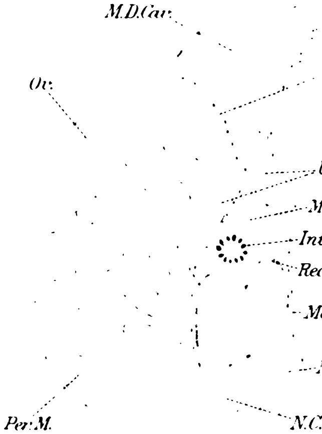

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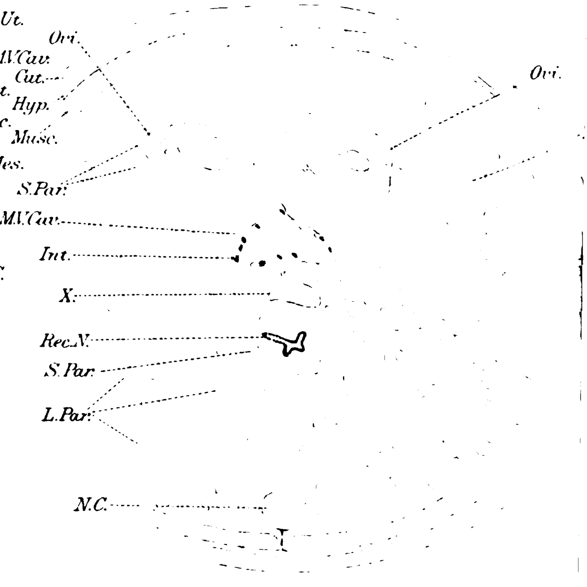


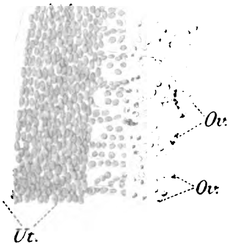
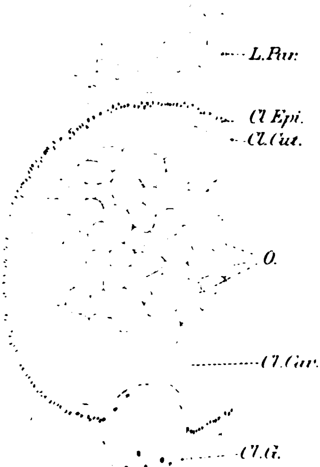


Fig. 67.

Fig. 70.

Montgomery gez.



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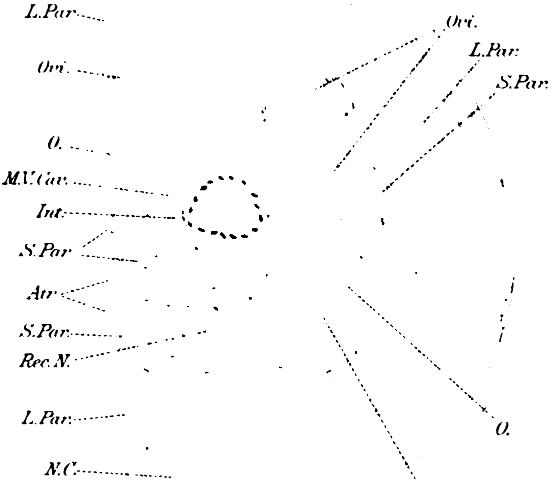

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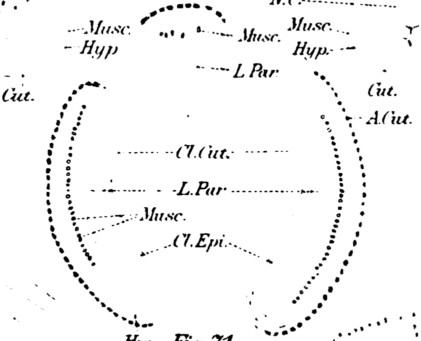

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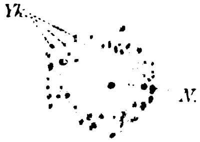

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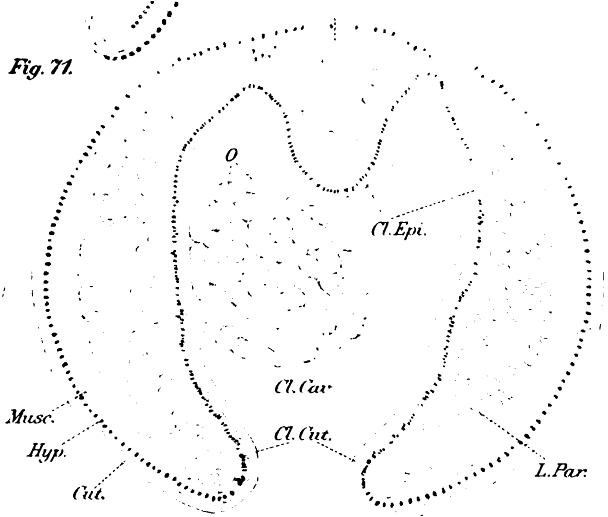

Fig. 73.

Fig. 74.

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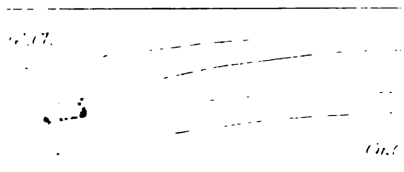

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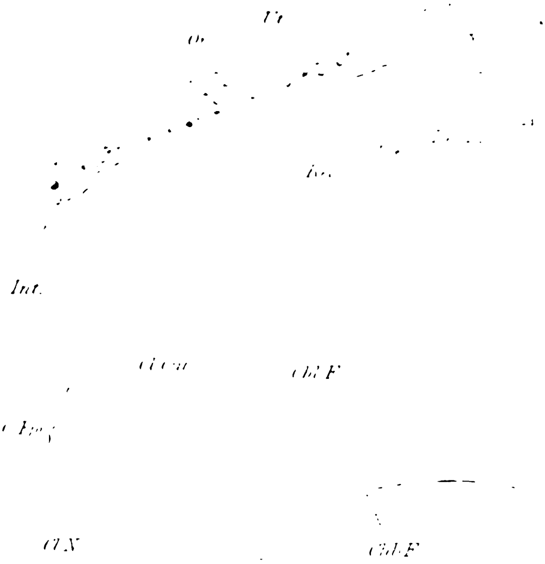

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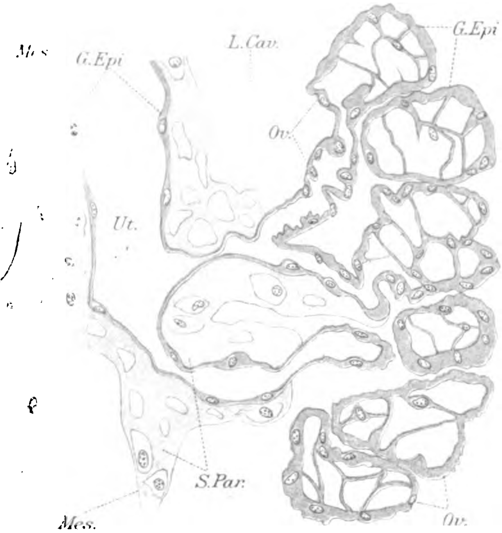

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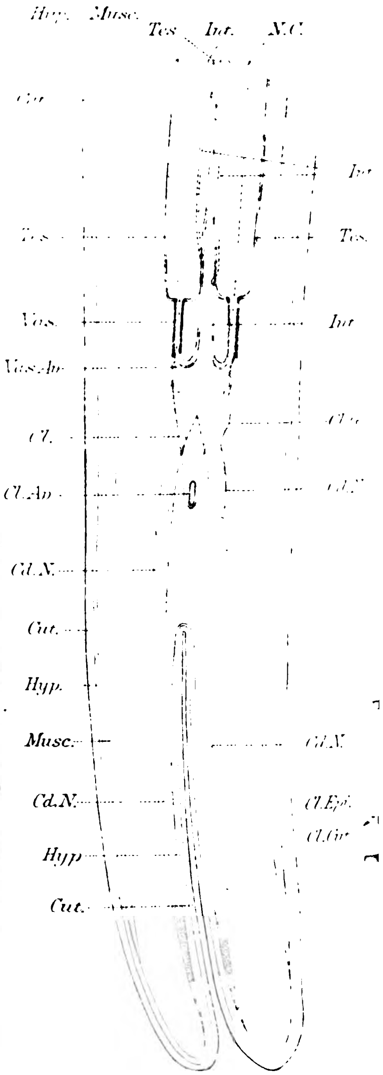

Fig. 81.

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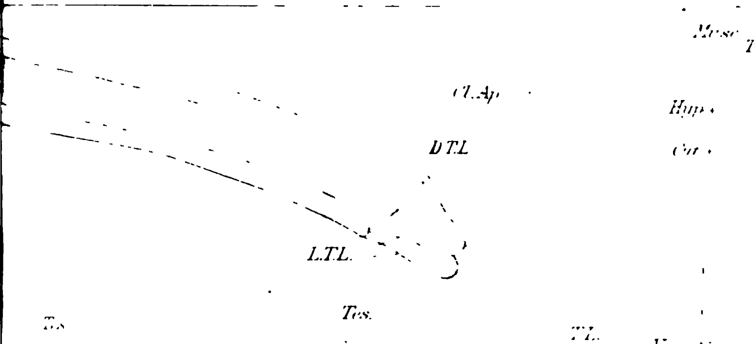

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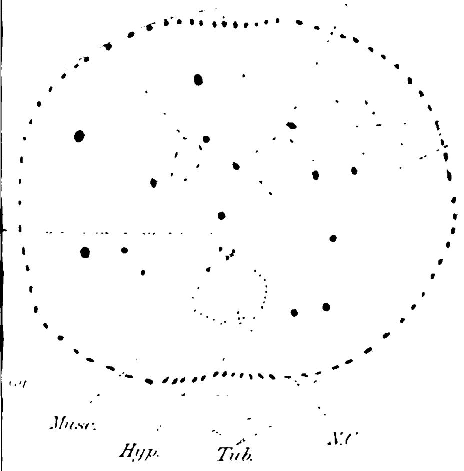

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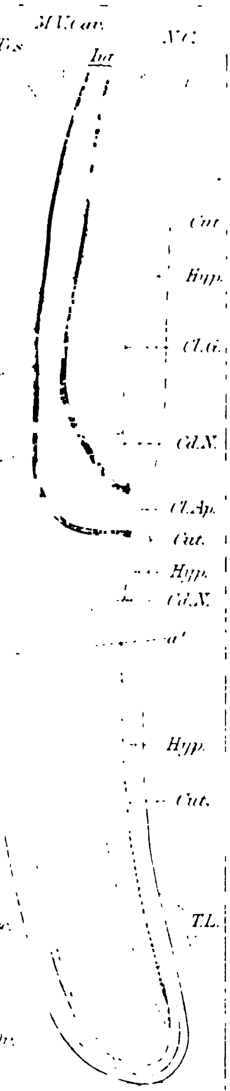

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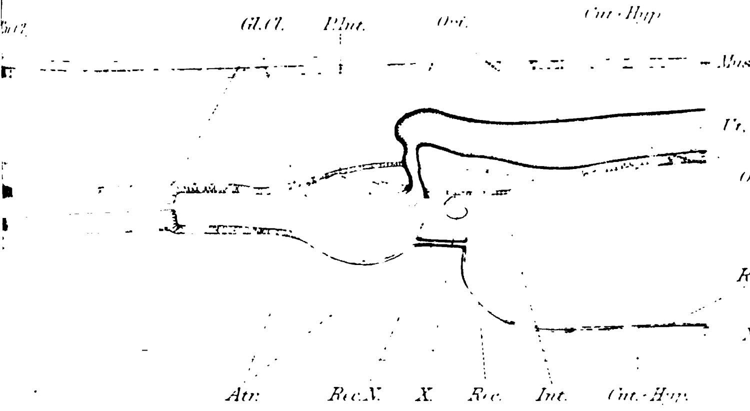

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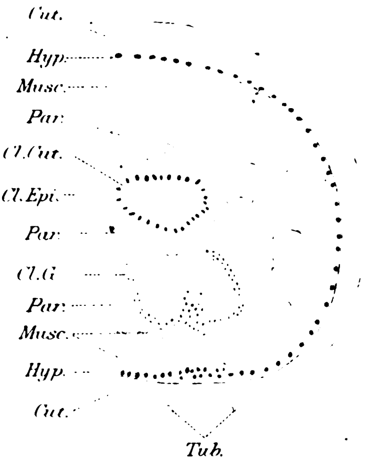

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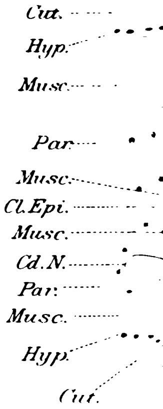

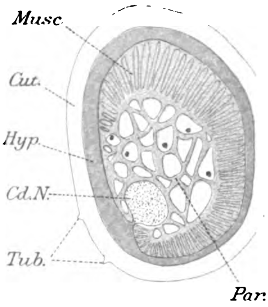

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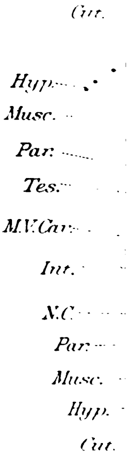

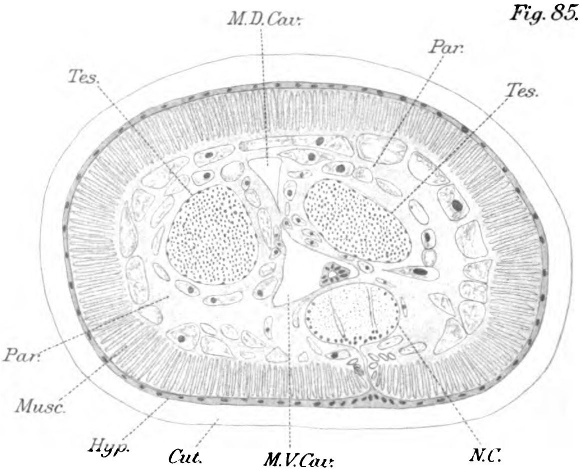

Fig. 84.

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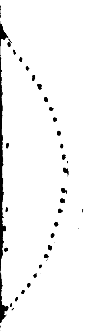


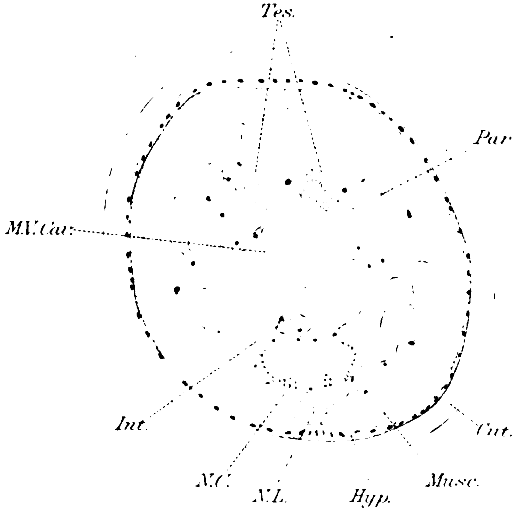
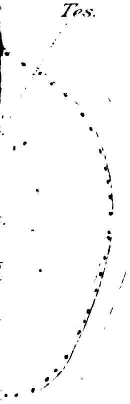


Fig. 90.

Fig. 91.



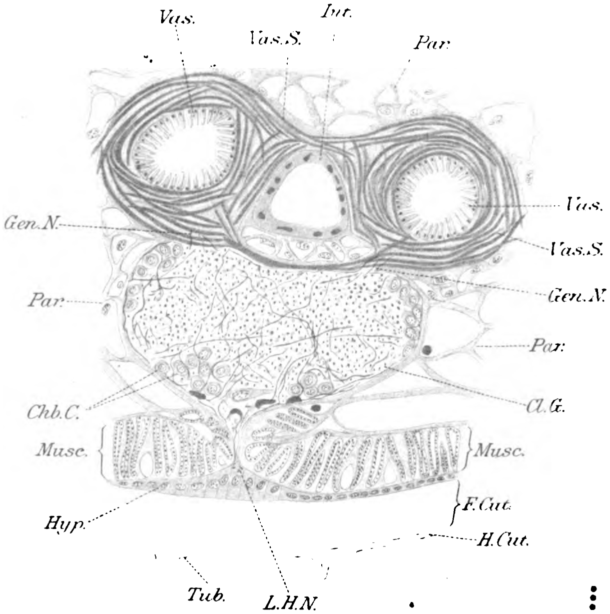


Fig. 89.

her in Jena.

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Frommannsche Buchdruckerei (Hermann Pohle) in Jena.